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and many others, thanks for all the good times, whether it was listening to each other's research, for some more of a one-way exchange, sharing the gastronomic atrocities served in the food plaza, playing futsal in the "tournament of Dutch economists", or discussing the more important matters of life over a good beer in the local pub.

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Contents

1

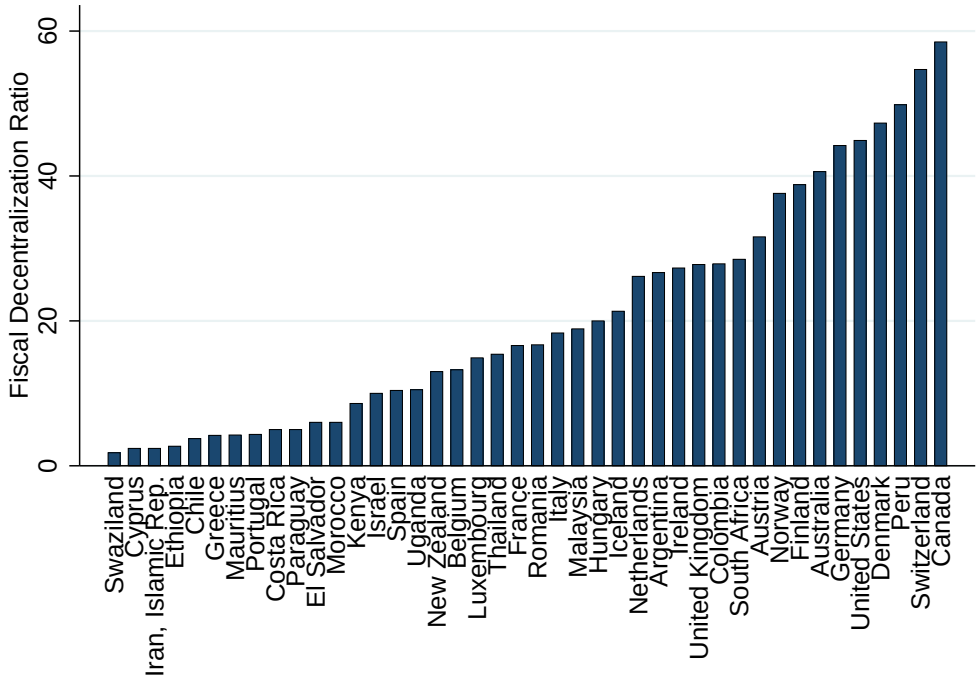
Introduction and Summary

In almost all countries in the world, the public sector consists of multiple levels. The highest level is the national level and is usually represented by the central government or federal government. Sub-national levels of the government may range from states, provinces, or regions that come directly below the national level, to counties, municipalities or cities at the local level. The government in a country may decide to devolve part of its responsibilities to these sub-national levels of the government. An important reason to do so is the believe that sub-national governments, because of their closer proximity to citizens, are better informed and more responsive to the specific wishes of these citizens. This advantage in preference matching and responsiveness is hoped to enable sub-national governments to find better and more effective ways to fulfill the wishes of the constituencies than their national counterparts (cf. Oates, 1999).

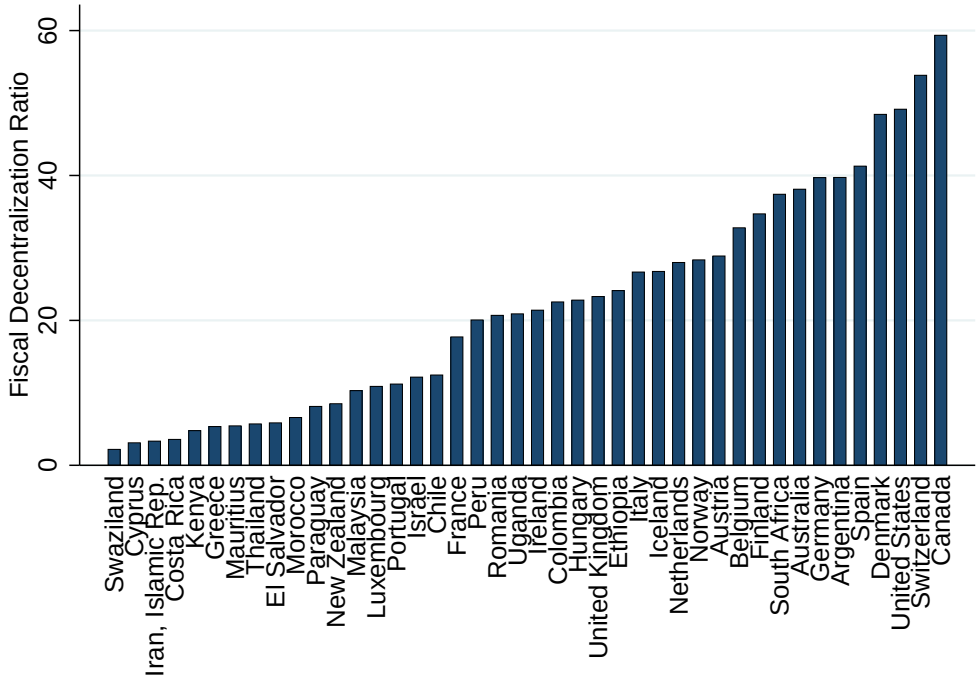
The degree to which governments devolve their responsibilities to sub-national levels of the government differs across countries. Figure 1.1 shows the share of sub-national government expenditures in total government expenditures, a widely used measure of the government's vertical structure, for several countries over the period 1972–1981 and the period 2001–2007. Some countries such as Cyprus, Greece, Morocco, and Iran are highly centralized, and almost all expenditures in these countries take place at the national level. Other countries such as Canada, Denmark, and Switzerland, where around half of all government expenditures take place at the sub-national government level, are highly decentraliza-

Figure 1.1: Fiscal Decentralization Ratios

(a) Period 1972-1981



(b) Period 2001-2007



Notes: Data are from the IMF's *Government Finance Statistics* (GFS) 2010.

tion not only differs across countries but also changes over time within countries. Argentina, Belgium, Chile, and Spain all became more decentralized, while Norway and Peru became more centralized.

The first part of this thesis looks whether differences in countries' vertical structure of the government are associated with differences in certain outcomes. More specifically, we look at the outcomes of fiscal decentralization since the measures of the government's vertical structure we use are based on expenditure and revenue data of the government. Studies that look at the outcomes of fiscal decentralization focus primarily on its possible economic efficieny improvements as a result of better preference matching and responsiveness of more decentralized governments. Other possible outcomes, such as the provision of public goods, governance, and the satisfaction with or amount of trust in the government receive far less attention or no attention at all. Chapter 2 empirically analyzes the relationship of fiscal decentralization and one of these alternative outcomes, namely the amount of trust citizens have in their government.

Although formal, or even informal, theories on the relationship between fiscal decentralization and trust in government are absent, we argue that the responsiveness advantages of more decentralized fiscal systems translate into a higher degree of citizens' trust in their government. We use repeated cross-section survey data of individuals to measure trust in government. This structure allows us to deal with some of the methodological concerns, such as a possible omitted variable bias, that may plague the relationship between fiscal decentralization and trust in government. We find that more decentralized fiscal systems are beneficial for trust in government. Since higher levels of trust may be beneficial for political and economic reasons (cf. Keele, 2007; Knack and Keefer, 1997), we argue that these trust benefits should be taken into account when making an assessment of the pros and cons of fiscal decentralization.

In Chapter 3, we take a closer look at the relationship between fiscal decentralization and economic growth. Despite the considerable attention it has received in the literature, there is no consensus on the possible economic efficieny improvements of more decentralized fiscal systems. Of more than fifteen studies considered, there are

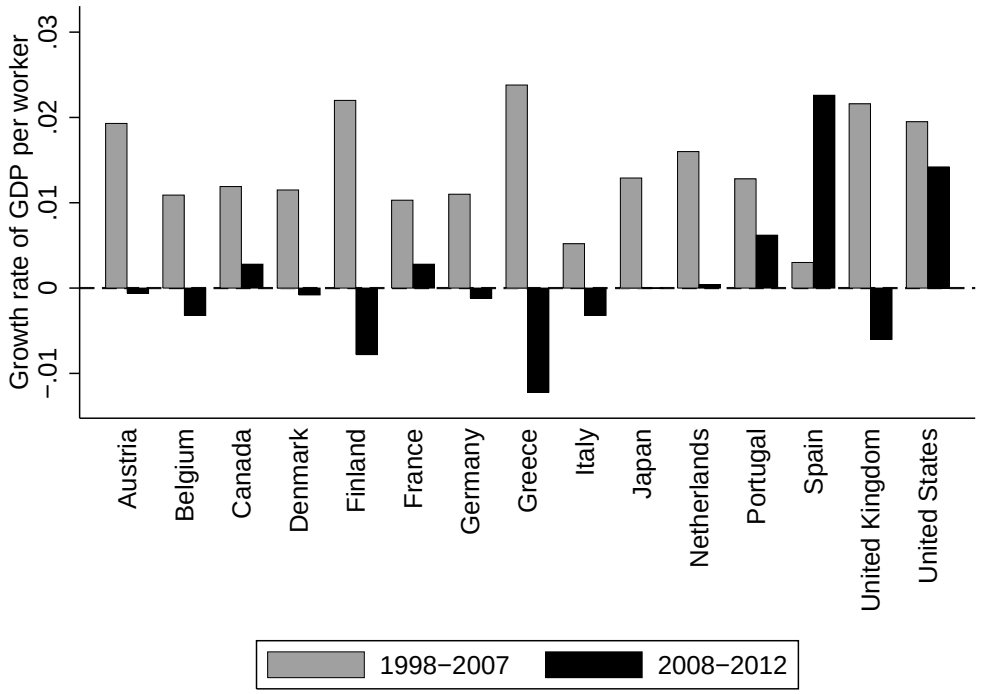
almost as many studies that find a positive, a negative, or no relationship. Differences in the number or type of countries, the time period of the analysis, estimation methods, empirical specifications, and data used make it hard to pin down an explanation for these results. More importantly, only a few of these studies deal with possible reverse causality problems, which is a concern regardless of any differences these studies may have. Another concern is the accuracy with which conventional government revenue and expenditure based measures of fiscal decentralization reflect the autonomy of sub-national governments. This concern has led to the use of alternative measures of fiscal decentralization, although a consensus of what the effect of doing so is compared to the use of conventional measures is absent. We address both concerns in this chapter.

We deal with possible reverse causality problems by introducing instrumental variables based on the origin of the legal system, the federal system, country size, and geographical distance. We argue that countries that are similar in these aspects share a similar process of fiscal decentralization. These instrumental variables are preferred over the ones used in the literature so far. Compared to standard internal instruments, such as the lag of fiscal decentralization itself, they do not lead to a loss of observations, and they are stronger instrumental variables than conventional external instruments. Using a sample of 56 countries over the period 1990–2007, we find evidence that fiscal decentralization is beneficial for economic growth. The use of alternative measures for fiscal decentralization that capture the autonomy of sub-national governments better than the conventional ones may change this outcome. However, this result seems more likely to be caused by the accompanied changes in the sample rather than the use of the alternative fiscal decentralization measures themselves.

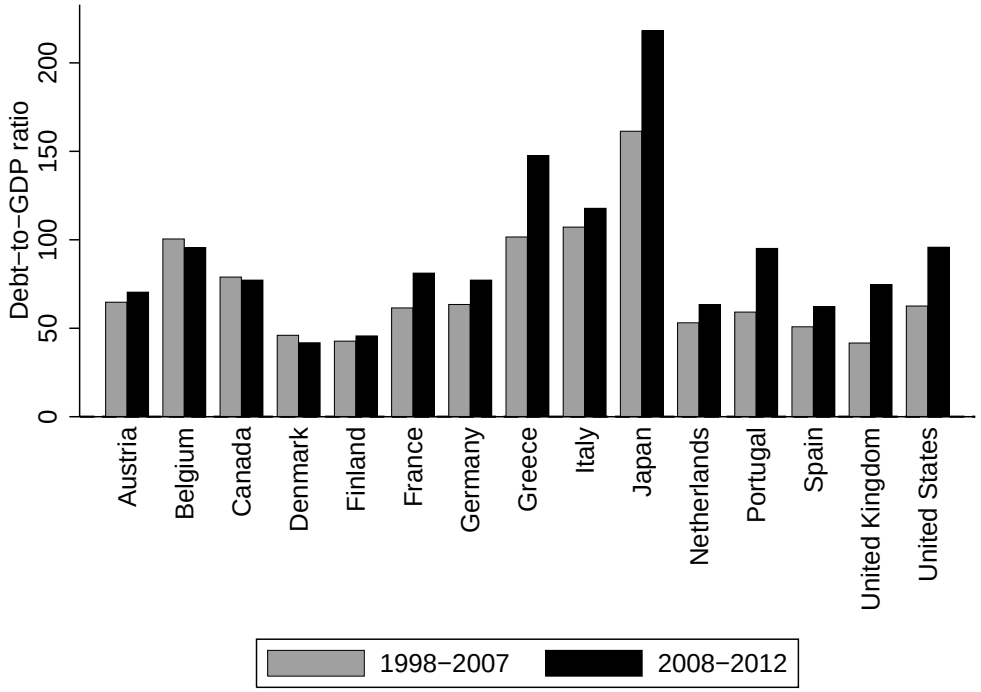
The second part of this thesis leaves the notion that governments can devolve part of their responsibilities to lower government levels. Rather, it treats governments as single-level entities that have to deal with certain challenges. The challenge discussed in this part of the thesis can best be described as a fiscal dilemma. More specifically, governments face the challenge to develop fiscal systems, or set fiscal policies, such that they result in sufficient revenues to deal with long-run budget challenges and

Figure 1.2: Growth of GDP per worker and Debt-to-GDP ratio

(a) Average Annual Growth rate of GDP per worker



(b) Average Debt-to-GDP ratio



Notes: Data are from the AMECO 2012 database and author's own calculations .

promote economic growth at the same time. These objectives are a challenge since taxes used by the government to raise these revenues harm economic activity, deter investments, and likely lead to lower economic growth.

Although governments always face this fiscal dilemma, it seems especially relevant in the last few years. Figure 1.2 shows the average annual growth rate of gross domestic product (GDP) per worker and the government debt-to-GDP ratio over the last 15 years for several countries, where the time period is divided in two parts, 1998–2007 and 2008–2012. For most of the countries, the average growth rate of GDP per worker in these last five years is considerably lower than it was a decade before that. For example, Finland went from an average annual growth rate of over 2 percent to a growth rate of almost minus 1 percent. At the same time, the average debt-to-GDP ratio became larger in these last couple of years for most of the countries. Hence, in the recent years where economic activity came to a standstill or even declined, the long-run budget challenges of the government became even harder.

Lowering tax rates to deal with this fiscal dilemma seems a very counterintuitive measure. However, one may believe that the stimulating effects that these lower taxes have on economic activity partly, or even more than completely, offset the initial loss in tax revenues. This notion is best illustrated by the Laffer curve (Laffer, 1979), which describes an inverted u-shaped relationship between the level of a tax rate and the amount of revenues it can raise. The possibility that tax cuts can fully pay for themselves is very unlikely. The levels of tax rates or behavioral elasticities necessary for such a situation to occur would be too large to be justified empirically (e.g., Fullerton, 1982). A lot of these studies used static partial equilibrium models, ignoring general equilibrium effects and long-run implications of fiscal policies. This leaves the question whether a tax cut can partly, or completely, pay for itself over time open.

Ireland (1994) is one of the first to show that it is possible for tax cuts to pay for themselves when the stimulating effects of these tax cuts in the long run are taken into account. However, this finding is not undisputed. Other studies show that such a dynamic Laffer curve, or dynamic Laffer effect, is not possible or depends on the value of behavioral elasticities, in this case the intertemporal elasticity of

substitution. Chapter 4 looks at these conflicting results. Using a simple dynamic general equilibrium framework, we decompose the dynamic Laffer effect in three basic effects, namely the direct budget effect, the growth rate effect, and the discount rate effect. This decomposition enables us to reconcile the different results found in the literature. The necessary assumption for a dynamic Laffer effect to occur is not related to the value of the behavioral elasticities, but it is the assumption that governments should commit to a path of expenditures that is growing at a lower rate than the economy itself. Under this assumption, resources are being freed up in the future that are used to make up the initial loss in revenues caused by the tax cuts. If this condition is satisfied, fiscal instruments with lower initial tax bases, such as the tax rate on capital income, are more likely to lead to a dynamic Laffer effect.

Studies that look at the impact of fiscal policies on the long-run budget balance of the government and the economy are referred to as 'scoring exercises'. These scoring exercises are a useful tool to look at the above described fiscal dilemma. Chapter 5 performs such a scoring exercise. In contrast to related studies, which mainly use neo-classical models where the growth rate is taken as given (e.g. Mankiw and Weinzierl, 2006), we use a model where economic growth is the result of intentional research and development by firms. Such a framework is especially interesting since it usually features monopolistic distortions and some form of externalities, lending itself to study active government policies. Of course, studying fiscal policies of the government only makes sense if government activities are properly taken into account. We address this issue by looking at a wide array of fiscal instruments such as tax incentives with respect to research effort, tax rates on capital income, labor income and consumption, and government expenditures. Moreover, the model covers almost all government expenditures and revenues that are listed in the national accounts.

From the scoring analyses we perform, it follows that allowing for more generous tax incentives with respect to research effort is the least costly way, in terms of the impact on the government budget, to stimulate economic activity. This policy is on average almost three times as cost effective as lowering the tax rate on capital income, which is the next best policy. We never obtain a dynamic Laffer effect for the

fiscal policies considered. This last finding can be explained by the relatively large deterioration of the government budget balance in the short run compared to the resulting efficiency gains of these policies in the long run. Also, when non-distorting financing options are unavailable, more generous tax incentives with respect to research effort can best be financed by cutting government expenditures and raising the tax rate on consumption. Finally, the model we develop has closed form solutions in equilibrium, features tractable transitional dynamics, and comes with a graphical apparatus that provides a clear insight in the mechanisms that are at work after a change in a fiscal instrument. This makes it suitable to also study questions other than dynamic scoring exercises.

2

In Government We Trust: The Role of Fiscal Decentralization[1]

2.1. Introduction

During the last decades, many developed and developing countries have devolved parts of their fiscal policy-making authority to sub-national levels of government. This process of fiscal decentralization has been promoted by changes in the geopolitical landscape—such as the enlargement of the European Union and the breakup of the former Soviet Union—dissatisfaction with the role of the central government in policy setting, and the policy advice of the World Bank (Tanzi, 1995). International policy institutions like the World Bank emphasize the improvements in allocative efficiency resulting from more decentralized fiscal systems. The general notion is that sub-national governments are better at delivering public goods that match local preferences or providing a given level of public goods at lower cost or both (cf. Oates, 1972, 1999).

Various empirical studies have measured the potential effects of fiscal decentralization on allocative efficiency. In particular, a lot of attention has been paid to the question whether fiscal decentralization can boost economic growth. So far, the empirical evidence on the fiscal decentralization and economic growth nexus is mixed.[2]

[1] This chapter is based on Ligthart and Van Oudheusden (2011).

[2] Davoodi and Zou (1998) and Zhang and Zou (1998) find evidence of a negative relationship between fiscal decentralization and economic growth, whereas Thiessen (2003) and Iimi (2005) show that fiscal decentralization enhances economic growth. Others do not find a significant relationship (Woller and Phillips, 1998; Thornton, 2007).

The strong focus on the dynamics of allocative efficiency implies that other possible favorable effects of fiscal decentralization, such as lower corruption, a more effective provision of public goods, and improved governance, have received less attention.[3] More important, some political-economy aspects of fiscal decentralization, such as the effect on trust in government—defined as the 'judgment of the citizenry that the system and the political incumbents are responsive, and will do what is right even in the absence of constant scrutiny' (Miller and Listhaug, 1990, p. 358)—and political institutions, have not received any attention at all. This chapter investigates whether fiscal decentralization promotes trust in government. To our knowledge, we are the first to analyze this relationship in a systematic way.

Why is it interesting to look at trust in government? From a political science perspective, trust in government is important for political leadership and governance. More specifically, a larger degree of trust in government makes it easier to commit resources that are needed for collective action or to obtain citizens' compliance with policy without coercion (Keele, 2007). Moreover, from an economic perspective, more trust in government may indirectly contribute to improved economic performance. Knack and Keefer (1997) show that a higher level of trust in government is associated with a higher level of 'social capital,' which Putnam (2000, p. 19) defines as 'connections among individuals—social networks and the norms of reciprocity and trustworthiness that arise from them.' A larger stock of social capital, in turn, induces a higher rate of economic growth.[4] These governance and macroeconomic benefits make it particularly interesting to understand what factors contribute to trust in government.

This chapter is related to studies analyzing the determinants of trust defined more generally, which can be either trust in persons or institutions.[5] Brehm and Rahn (1997), Alesina and Ferrara (2002), Keele (2007), and Gustavsson and Jordahl (2008) study the determinants of trust using data for a single country. Except

[3]Exceptions are Treisman (2000) and Fisman and Gatti (2002), who study empirically the effect of fiscal decentralization on corruption, and Enikolopov and Zhuravskaya (2007), who study its effect on governance and public goods provision.

[4]Not only Knack and Keefer (1997), but also Rodrik (1999) and Zak and Knack (2001) find that economic growth rises with social capital.

[5]The definitions of trust in persons—also referred to as interpersonal trust—differ in the literature on trust, but generally refers to citizens' confidence in each other as members of a community.

for Gustavsson and Jordahl (2008), who use Swedish data, all studies pertain to the United States. Knack and Keefer (1997) and Zak and Knack (2001) employ data for several countries to explain cross-country differences in trust. None of these studies, however, investigate the effect of fiscal decentralization on trust. This chapter is also somewhat related to papers studying aggregate determinants of individual outcomes.[6] Of these studies, the one that comes closest to ours is that of Bjornskov et al. (2008), who analyze the effect of fiscal decentralization on subjective well-being.

We use an ordered response model to analyze the effects of fiscal decentralization on several measures of trust in government defined in a broad sense (i.e., the government, civil services, parliament, and political parties). These measures of trust in government—which are obtained from the *World Values Survey*—pertain to up to 35,259 individuals from 13 countries over the period 1994–2007. We take into account a wide array of determinants of trust at both the individual and aggregate level. Because we use data from multiple surveys over time for a given country (i.e., a repeated cross section, where the respondents differ by survey), we can control for country characteristics that are correlated with fiscal decentralization. On the methodological side, we thereby extend Mishler and Rose (2001) and Bjornskov et al. (2008), who do not control for this unobserved country heterogeneity.

Controlling for various macroeconomic determinants, individual determinants, and unobserved country characteristics, we find that fiscal decentralization increases trust in government. More specifically, a one standard deviation increase in fiscal decentralization causes on average half a standard deviation increase in trust in government, which is defined as the share of the population that indicates to trust the government.[7] The beneficial effect of fiscal decentralization on trust in government is neither limited to nor necessarily large for relatively decentralized countries; that is, the effect on trust in government can be relatively small for countries with a highly decentralized fiscal system (e.g., Australia and Germany).

The remainder of this chapter is organized as follows. Section 2.2 presents some

[6] See the Mishler and Rose (2001), Di Tella et al. (2003), and Bjornskov et al. (2008).

[7] The effect is based on the average effect of fiscal decentralization on the measures of trust in government as described above. The population share that trusts the government is based on respondents that indicate to have a great deal or quite a lot of confidence in these institutions; see Section 2.2 for more details.

theoretical considerations and discusses the data on trust in government and fiscal decentralization. Section 2.3 sets out the methodology employed in estimating the effect of fiscal decentralization on trust in government. Section 2.4 presents the results, performs robustness checks, and addresses endogeneity concerns. Section 2.5 concludes the paper.

2.2. Trust in Government and Fiscal Decentralization

This section sheds light on the relationship between fiscal decentralization and trust in government. We first present some theoretical considerations. Subsequently, we provide a descriptive analysis of this relationship.

2.2.1. Theoretical Considerations

The formal literature on the non-economic benefits of fiscal decentralization is sparse. Theories describing the link between fiscal decentralization and trust in government are absent. However, existing theories on the economic benefits of fiscal federalism are a good starting point in discussing the potential relationship between trust in government and fiscal decentralization. One of the basic arguments in favor of fiscal decentralization is provided by Tiebout (1956) and Oates (1972, 1999), who claim that fiscal decentralization improves allocative efficiency. They reason that sub-national governments have more information than national governments about local preferences, reflecting their proximity to households. Accordingly, sub-national governments are better at matching the provision of public goods to local preferences than national governments. We hypothesize that improved preference matching may not only translate into higher efficiency but also into more trust in government.

The above line of reasoning can also be extended to several other arguments in support of fiscal decentralization such as Oates's (1999) 'laboratory federalism' or the competition argument of Brennan and Buchanan (1980). Oates (1999, p. 1132) argues that 'in a setting of imperfect information with learning-by-doing, there are potential gains from experimentation with a variety of policies for addressing social and economic problems' and that the conditions to do so may be better

when sub-national governments have fiscal policy-making authority. In other words, fiscal decentralization creates an environment that may foster more effective public policies. Brennan and Buchanan (1980) argue that fiscal decentralization increases jurisdictional competition, which constrains the total size of the public sector. Again, this may not only lead to more efficient public service delivery but also to higher trust in government.[8] Therefore, we propose the following hypothesis:

Hypothesis. *A larger degree of fiscal decentralization promotes trust in government.*

Besides the direct effect of fiscal decentralization on trust in government, there could also be an indirect effect. For example, fiscal decentralization may increase the quality of the government, which in turn could increase trust in government. However, the fiscal decentralization literature provides little to no guidance on the transmission channels. Because we are interested in the direct effect, we will control for potential indirect channels in our empirical analysis.

2.2.2. Data on Trust in Government and Fiscal Decentralization

The measures of trust in government are obtained from the *World Values Survey* of the World Values Survey Association (2009). Our data are taken from three waves of interviews of this survey, which cover up to 35,259 individuals over the period 1994–2007. More specifically, we use data from the 1994–1999, 1999–2004, and 2005–2007 wave. Given that we do not have countries in our sample with interviews in 1999, we use data over the period 1994–1998 for the 1994–1999 wave, so we have three non-overlapping time periods; that is, 1994–1998, 1999–2004, and 2005–2007.

Although the *World Values Survey* dataset we use consists of 80 countries for which data on our dependent variables are available, we consider two samples of 10 and 13 countries, respectively, that only partially overlap. Because of data limitations implied by our choice of covariates, we had to drop a large number of countries and observations. The majority of observations and countries drops due to the lim-

[8]Fiscal decentralization may also give rise to costs. Shleifer and Vishny (1993) point to the possibility of soft budget constraints at the local level, causing excessive debt accumulation.

ited availability of fiscal decentralization data (38 countries).[9] We have also removed six countries with missing determinants at the individual level and 19 countries with missing data on the remaining aggregate level determinants. We include only countries with at least two waves of surveys and matching fiscal decentralization data so that we can control for country-specific fixed effects; see Section 2.3.1. The final samples consist of selected OECD members, Eastern European and Latin American countries. Tables A.1 and A.2 in the Appendix show the trimming procedure and distribution of the interviews over the countries and waves for the two samples we consider, respectively.

To capture trust in government, we study several governmental institutions. This approach accommodates differences in the degree to which survey respondents may experience or have knowledge about these institutions. For instance, survey respondents may have a better grasp of the operations and performance of civil services rather than the government because they had direct dealings with civil servants in their town hall. In view of this approach, we employ four measures of trust in government: (i) confidence in government; (ii) confidence in civil services; (iii) confidence in parliament; and (iv) confidence in political parties. All four measures are answers to the following question: 'I am going to name a number of organizations. For each one, could you tell me how much confidence you have in them?' Survey respondents had to indicate their level of confidence on the following scale: 'a great deal of confidence,' 'quite a lot of confidence,' 'not very much confidence,' or 'none at all.'

We follow Alesina and Ferrara (2002) in defining confidence in organizations as trust in institutions. Moreover, since our selected organizations have in common that they all cover a dimension of government, we define confidence in those organizations as measures of trust in government. A somewhat similar approach is taken by Knack and Keefer (1997), who define confidence in government in a broad sense by taking an average of confidence in education, the legal system, the police, and the civil service rather than looking at these institutions individually. Mishler and Rose

[9]Table B.3 of Ligthart and Van Oudheusden (2012b) shows the availability of fiscal decentralization data by country.

(2001) define political trust by taking the average of trust in parliament, the prime minister or president, courts, police, political parties, and the military.[10] Compared to these studies, we employ more narrowly defined concepts of government and do not average over government-related institutions. Indeed, Table 2.1 shows that our different measures of trust in government are not very strongly correlated; the correlation coefficients range from 0.45 to 0.68 and are significant at the 1 percent level.

Table 2.1: Correlation Coefficients of Government Trust Measures

	Civil Services	Parliament	Political Parties
Government	0.47***	0.68***	0.55***
Civil Services		0.55***	0.45***
Parliament			0.64***

Notes: Based on the large sample of 13 countries; see Table A.2. ***, **, * denote significance at the 1, 5, and 10 percent level, respectively.

In line with most of the fiscal federalism literature, we measure fiscal decentralization as the share of sub-national government expenditures in general government expenditures. The data are taken from the 2010 edition of the IMF's *Government Finance Statistics* (GFS). Based on the IMF's *GFS Manual* (2001), sub-national expenditures are defined as expenditures on both the state and local government level, where the state level refers to the largest geopolitical entity within a country and the local level describes the smallest governmental units.[11] General government expenditures encompass public expenditures on the central, state, and local government level.[12] This measure of fiscal decentralization has been criticized by Martinez-Vazquez and McNab (2003) and Thornton (2007) for not accurately representing the degree to which sub-national governments have policy autonomy. The

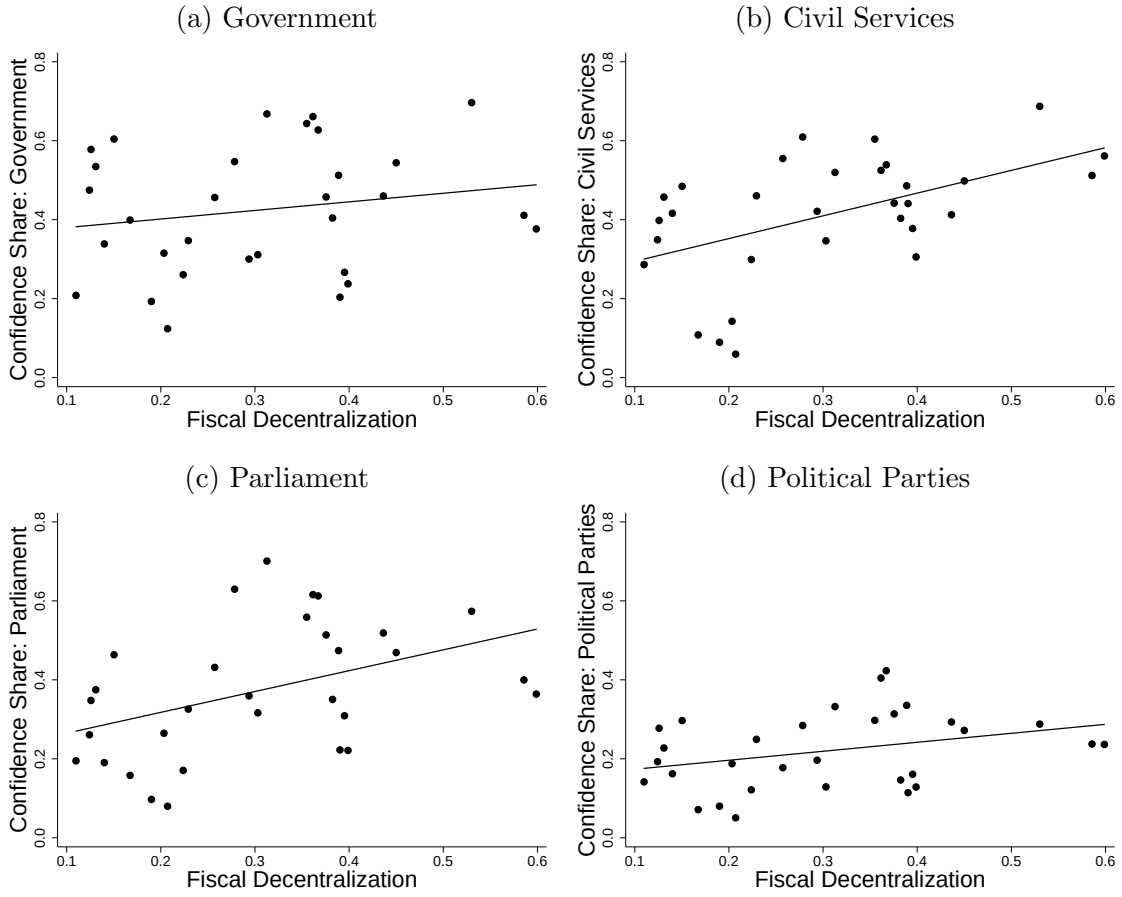
[10]Brehm and Rahn (1997) and Alesina and Ferrara (2002) investigate confidence in the executive branch of the federal government.

[11]Some countries (e.g., the United States and Spain) have more than one level of government between the central level and the local level. In such cases, the *GFS Manual* groups the intermediate levels of government together with the level they are most closely associated with.

[12]Some studies use the share of sub-national revenue in general government revenues as an alternative measure (i.e., Enikolopov and Zhuravskaya, 2007). Typically, the revenue-based and expenditure-based decentralization measures are highly correlated. Ligthart and Van Oudheusden (2012b) show in Table B.7 that the main results of this paper can also be found using revenue-based measures.

OECD (1999) has developed an alternative measure of fiscal decentralization, which takes into account various categories of tax autonomy of sub-national governments. However, the OECD indicator is not available for the samples we are considering and, therefore, we resort to the standard indicator used in the literature. We average the fiscal decentralization data over the years corresponding to the three specified time periods since fiscal decentralization data are not always available for the years in which the interviews took place. Average decentralization ratios during 1994–2007 vary between 0.13 for Chile and 0.59 for Canada.

Figure 2.1: Confidence Shares and Fiscal Decentralization



Notes: Based on the large sample of 13 countries and three time periods; see Table A.2. The horizontal axis measures the degree of fiscal decentralization and the vertical axis represents the confidence share, which is defined as the percentage of survey respondents of a country in a given wave that indicated to have either 'a great deal of confidence' or 'quite a lot of confidence.'

Figure 2.1 displays the unconditional relationships between the four measures of trust in government and fiscal decentralization. To facilitate a graphical presentation, we use an aggregate measure of trust in government, the so-called confidence share, which is defined as the percentage of survey respondents of a country in a given wave that indicated to have either 'a great deal of confidence' or 'quite a lot of confidence' (cf. Knack and Keefer, 1997). Panels (a)–(d) of Figure 2.1 show that the confidence share is increasing in the degree of fiscal decentralization, although it rises to a different extent for each measure. For instance, the unconditional relationship is much stronger for confidence in civil services than for confidence in government.

2.3. Empirical Methodology

This section sets out an ordered response model for trust in government, presents both individual-level and aggregate-level determinants, and discusses econometric issues.

2.3.1. The Ordered Response Model

Our dependent variable in the analysis is a measure of trust in government described in Section 2.2. Because the dependent variable is categorical and ordered, we use an ordered response model. To capture the repeated cross-sectional nature of our data—where households are different in each cross-section—we index individuals by $i(t)$, where $i(t) = 1, \ldots, I$ and $t = 1, \ldots, T$. More specifically, we estimate the following ordered logit model for individual $i(t)$ residing in country $j = 1, \ldots, J$ at time t:

$$y_{i(t)jt} = k \quad \text{if} \quad \mu_{k-1} < y^*_{i(t)jt} \leq \mu_k \quad \text{for} \quad k = 1, \ldots, K, \tag{2.1}$$

where k represents an index for the number of categories (where $K = 4$), μ_k is the upper cut-point for category k, and $y^*_{i(t)jt}$ is a latent dependent variable given by[13]

$$y^*_{i(t)jt} = \boldsymbol{\beta}' \mathbf{x}_{jt} + \boldsymbol{\gamma}' \mathbf{z}_{i(t)jt} + \eta_j + \phi_t + \varepsilon_{i(t)jt}, \tag{2.2}$$

[13]The category $y_{i(t)jt} = 4$ corresponds to the answer 'a great deal of confidence,' $y_{i(t)jt} = 3$ to 'quite a lot of confidence,' $y_{i(t)jt} = 2$ to 'not very much confidence,' and $y_{i(t)jt} = 1$ to 'none at all.' The categories $k = 1$ and $k = K = 4$ (i.e., the extreme categories) are open-ended intervals with $\mu_0 \to -\infty$ and $\mu_K \to \infty$. See Long (1997) for further details on the ordered logit model.

where $\mathbf{x}_{jt}$ is a vector of variables at the aggregate level (Section 2.3.2.1), including our measure of fiscal decentralization, $\mathbf{z}_{i(t)jt}$ is a vector of variables at the individual level (Section 2.3.2.2), and $\boldsymbol{\beta}$ and $\boldsymbol{\gamma}$ are vectors of parameters. The parameters η_j and ϕ_t are country-specific fixed effects and wave fixed effects, respectively, and $\varepsilon_{i(t)jt}$ is a logistically distributed error term with mean zero and variance $\pi^2/3$. We include country dummies to control for unobserved country-specific fixed effects such as culture. The potential effects of other time-invariant or highly persistent determinants (e.g., ethnic fractionalization, democracy, and political autonomy) are picked up by the country dummies as well. Wave dummies are employed to control for shocks common to all countries. Because the analysis includes covariates defined at the aggregate level while our dependent variable is measured at the individual level, the regression disturbances may be correlated. To ensure the disturbances are robust to dependency across individuals, we cluster the standard errors at the country-wave level (cf. Moulton, 1990).

The probability of individual $i(t)$ of country j choosing category k conditional on $\mathbf{x}_{jt}$ and $\mathbf{z}_{i(t)jt}$ is given by

$$\begin{aligned} \text{Prob}(y_{i(t)jt} = k|\mathbf{x}_{jt}, \mathbf{z}_{i(t)jt}) &= F(\mu_k - \boldsymbol{\beta}'\mathbf{x}_{jt} - \boldsymbol{\gamma}'\mathbf{z}_{i(t)jt} - \eta_j - \phi_t) \\ &- F(\mu_{k-1} - \boldsymbol{\beta}'\mathbf{x}_{jt} - \boldsymbol{\gamma}'\mathbf{z}_{i(t)jt} - \eta_j - \phi_t), \end{aligned}$$

where $F(\cdot)$ denotes the logistic cumulative density function of $\varepsilon_{i(t)jt}$. The corresponding log-likelihood function is given by

$$\ln L(\boldsymbol{\theta}|\mathbf{x}, \mathbf{z}) = \sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{k=1}^{K}\sum_{y_{i(t)jt}=k} y_{i(t)jt} \ln \text{Prob}(y_{i(t)jt} = k|\boldsymbol{\theta}, \mathbf{x}, \mathbf{z}), \tag{2.3}$$

where $\boldsymbol{\theta} \equiv [\boldsymbol{\beta} \;\; \boldsymbol{\gamma} \;\; \eta_j \;\; \phi_t \;\; \boldsymbol{\mu}]'$ is a row vector with parameters, and $\boldsymbol{\mu}$ is the vector of cut-points. For identification purposes, we set the constant to zero. Maximizing (2.3) gives the estimates of the coefficient vectors $\boldsymbol{\beta}$ and $\boldsymbol{\gamma}$, the fixed effects η_j and ϕ_t, and the cut-points μ_k.

2.3.2. Determinants of Trust in Government

We now discuss the determinants of trust in government at both the aggregate and individual level. Table A.3 in the Appendix presents descriptive statistics. We draw

on the literatures on trust in institutions in determining the expected sign of the determinants. Since there are only a few papers that deal with the determinants of trust in institutions, we also look at papers dealing with the determinants of trust in persons. Although Alesina and Ferrara (2002) find that these two forms of trust are not necessarily correlated, there is evidence that trust in persons is affected in the same way as trust in institutions (cf. Brehm and Rahn, 1997; Mishler and Rose, 2001).

2.3.2.1. Determinants at the Aggregate Level

Besides our variable of interest, the matrix $\mathbf{x}_{jt}$ contains controls at the aggregate level, which are measures of government quality, government size, income inequality, and both the level and volatility of the growth rate. Government quality is measured by the government effectiveness indicator, which is taken from the World Bank's *Worldwide Governance Indicators* (2008). The government effectiveness indicator captures the quality of public services, the capacity of the civil service and its independence from political pressures, and the quality of policy formulation. The indicator generally ranges from -2.5 to 2.5, where positive values reflect a better institutional quality. The empirical analysis of Zak and Knack (2001) reveals a positive relationship between interpersonal trust and the quality of institutions related to contract enforcement and corruption. Mishler and Rose (2001) find that both interpersonal trust and trust in institutions decrease with corruption. Although these studies do not investigate government quality, our measure of government quality is highly correlated with measures of institutional quality related to corruption. Therefore, we expect a positive relationship between government quality and trust in government.

We also control for the size of government in estimating the effect of fiscal decentralization on trust in government. Government size is measured by the share of general government final consumption expenditures in Gross Domestic Product (GDP), which is obtained from the World Bank's *World Development Indicators* (2010). To our knowledge, the relationship between government size and trust in institutions has not been analyzed directly. However, Brehm and Rahn (1997) find

that trust in institutions increases with life satisfaction and Bjornskov et al. (2008) show that life satisfaction decreases with government size. In view of this, we expect a negative relationship between government size and trust in government.

Income inequality is included to control for the effect of the income distribution on trust in government. We measure income inequality by the Gini coefficient, which is constructed using data taken from the *World Income Inequality Database* (2008) of the World Institute for Development Economics Research.[14] The analysis of Alesina and Ferrara (2002) shows that the Gini coefficient is not related to trust in institutions. However, Brehm and Rahn (1997), Knack and Keefer (1997), Zak and Knack (2001), and Alesina and Ferrara (2002) do find a negative effect of the Gini coefficient on interpersonal trust. The analysis of Gustavsson and Jordahl (2008) does not find support for this relationship, but presents evidence of a negative relationship with other measures of income inequality. Hence, we expect a non-positive relationship between the Gini coefficient and trust in government.

We include the level and the volatility of the growth rate of real GDP per capita to control for the effects of each country's macroeconomic performance on trust in government. We use the growth rate of real GDP per capita rather than its level given the possible problems of regressing untrended trust measures on likely trended variables such as the GDP per capita; see Di Tella et al. (2003).[15] The growth rate is defined as the growth rate of GDP per capita at purchasing power parity (measured in 2005 international dollars). The volatility of the growth rate is measured by the standard deviation of the growth rate calculated based on the three specified time periods. Mishler and Rose (2001) find that trust in institutions increases with the GDP growth rate. However, Knack and Keefer (1997) and Zak and Knack (2001) do not find a relationship between the level of GDP per capita and trust, where Knack and Keefer (1997) look at trust in institutions and Zak and Knack (2001) at interpersonal trust. Therefore, we expect a non-negative relationship between the

[14]The database provides Gini coefficients based on different categories of income definition, type of income adjustment, area coverage, and data quality ratings. In addition, per category there are multiple measures per country per year. To construct one Gini coefficient per country per year, we applied the following preference ranking: consumption-based measures are preferred over income-based measures, national estimates are preferred over urban and rural estimates, and high-quality data are preferred over low-quality data.

[15]The main results do not change when replacing the growth of GDP per capita with the log of GDP per capita.

growth rate of real GDP per capita and trust in government. The literature has not studied the effect of the volatility of the growth rate on trust yet. In view of the negatively sloped frontier between the growth rate and volatility of the growth rate (cf. Ramey and Ramey, 1995), the above relationship is likely to be negative.

2.3.2.2. Determinants at the Individual Level

The matrix $\mathbf{z}_{i(t)jt}$ contains a set of explanatory variables at the individual level—all are taken from the *World Values Survey*—which are measures of interpersonal trust, gender, age, education, income, social class, and the importance of politics in life. We are interested in estimating the effect of fiscal decentralization on government confidence above and beyond the effect of interpersonal trust. This means that interpersonal trust corrects for the respondent's general level of trust, therefore controlling for any personal bias in the subjective dependent variable. Interpersonal trust takes the value one if survey respondents indicated that 'most people can be trusted' and zero otherwise. Knack and Keefer (1997) find a positive relationship between interpersonal trust and trust in institutions based on data at the aggregate level. Using data at the individual level, the analysis of Brehm and Rahn (1997) yields a similar result. Alesina and Ferrara (2002) analyze the correlation between interpersonal trust and trust in several institutions employing data at the individual level. They find that interpersonal trust is positively related to trust for some government-related institutions, but these correlation coefficients are rather small.[16] Therefore, we expect a positive relationship between interpersonal trust and trust in government.

Gender takes the value one if the survey respondent is male and zero otherwise. Age and education are both represented by three categories: for age these are 15–24, 25–34, and 35–44, and for education these are lower, middle, and upper. Income is represented by 10 categories, where category one corresponds to the lowest and 10 to the highest income level. Note that income levels denote the income deciles of the survey respondents' countries. Mishler and Rose (2001) find that both interpersonal

[16]For example, interpersonal trust has the strongest relationship with confidence in the executive branch of the federal government but the corresponding correlation coefficient is only 0.06 (Alesina and Ferrara, 2002, p. 216).

trust and trust in institutions increase with age, but are not related to gender, education, or income. The studies by Alesina and Ferrara (2002) and Gustavsson and Jordahl (2008) find that interpersonal trust increases with income and education. In contrast, Alesina and Ferrara (2002) show that interpersonal trust is lower for women than for men and is increasing in age, while Gustavsson and Jordahl (2008) reveal that interpersonal trust is not related to gender or age. Hence, we expect that trust in government is either not related to gender or higher for men and is non-negatively related to age, education, and income.

Social class is represented by five categories: upper, upper middle, lower middle, working, and lower class. The four categories representing the importance of politics in life are based on survey respondents' answers, which vary from 'not at all important' to 'very important.' To our knowledge, the literature does not provide a hypothesized sign for these covariates, but we expect them to be positively related with trust in government.

Finally, as a robustness check, we include a dummy measuring whether an individual is unemployed to control for economic performance effects at the individual level. Brehm and Rahn (1997), Mishler and Rose (2001), and Gustavsson and Jordahl (2008) point out that interpersonal trust is lower for individuals that are unemployed. Mishler and Rose (2001) find the same relationship for trust in institutions rather than interpersonal trust. We expect trust in government to be negatively related to individual unemployment.

2.3.3. Endogeneity

One concern is the potential reverse causality of fiscal decentralization and trust in government. Citizens' trust in government may affect politician's reelection probabilities. Politicians in turn shape the political decision process on the appropriate degree of fiscal decentralization. In Tanzi's (1995) view, however, the devolution of fiscal policy-making authority is unrelated to trust in government. In view of these conflicting lines of reasoning, it is worthwhile to investigate the fiscal decentralization and trust in government nexus further.

One could test for the potential endogeneity of fiscal decentralization by using an instrumental variables (IV) approach. However, in the context of an ordered

logit model, this is not a straightforward procedure given that our left-hand side variable consists of four categories. Furthermore, traditional instruments for fiscal decentralization such as the origin of a country's legal system (Fisman and Gatti, 2002) and country size (Enikolopov and Zhuravskaya, 2007) are time invariant and thus drop out in an analysis with country fixed effects. Therefore, we do not resort to an IV approach. Instead, we follow Di Tella et al. (2003)—who also study the effect of aggregate variables on outcomes at the individual level—by lagging our variable of interest by one time period to deal with the problem of reverse causality. More precisely, we lag fiscal decentralization by taking the average degree of fiscal decentralization of the three years preceding the wave in which the interviews took place. Since those data are not available for all countries, there is a reduction in sample size. To alleviate the loss of observations, we use the large sample rather than the small sample and look at both current and lagged fiscal decentralization. As a second approach, Di Tella et al. (2003) include the lags of all variables at the aggregate level and use the contemporaneous values of variables at the individual level that are truly exogenous (e.g., age and gender).

2.4. Estimation Results

Section 2.4.1 discusses the benchmark estimation results and Section 2.4.2 performs robustness checks and deals with endogeneity issues.

2.4.1. Benchmark Analyses

2.4.1.1. Effects of Determinants at the Aggregate Level

Panel (a) of Table 2.2 presents the ordered logit estimation results for determinants at the aggregate level using the small sample of 22,794 individuals. In all regressions, we include wave dummies, country dummies, and the determinants at the individual level, except for the employment status, as discussed in Section 2.3.2.2. Column (1) of Table 2.2 regresses confidence in government on fiscal decentralization. Columns (2), (3), and (4) add the quality and size of the government, income inequality, and

macroeconomic performance indicators, respectively.

In all cases, fiscal decentralization enters with a positive and significant coefficient. Because of the nonlinear nature of the model, the estimated coefficients do not represent marginal effects. Section 2.4.1.3 discusses the interpretation of the size of the effect of fiscal decentralization on trust in government. In line with expectations, both government size and income inequality feature a negative and significant coefficient. The 2005–2007 wave coefficient is negative and significant, except for the case where we include all covariates at the aggregate level. The coefficients of government quality, the macroeconomic performance indicators, and the 1999–2004 wave are not significant.

In columns (5)–(8) of the table, we estimate the same set of specifications for confidence in civil services. The results are very similar to the previous results. Fiscal decentralization is positively related to confidence in civil services and both government size and income inequality enter with a negative and significant effect. The coefficients of the macroeconomic performance indicators and the 1999–2004 wave are again not significant. In contrast to confidence in government, the coefficient of government quality is now positive and significant and the 2005–2007 wave coefficient is always negative and significant.

Table 2.2: Trust in Government and Fiscal Decentralization
Panel (a): Aggregate Level

	Government				Civil Services			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Fiscal decentralization	4.618***	4.431***	5.373***	4.246**	4.318**	4.255**	5.358***	3.236***
	(1.40)	(1.67)	(1.40)	(1.93)	(2.02)	(2.06)	(1.71)	(1.11)
Government quality		0.508	0.714	0.620		0.743**	0.996***	1.157***
		(0.52)	(0.45)	(0.41)		(0.37)	(0.29)	(0.22)
Government size		-5.321*	-6.769***	-5.747**		-3.390	-5.155**	-7.356***
		(3.06)	(2.57)	(2.58)		(3.26)	(2.49)	(2.06)
Income inequality			-6.082***	-5.371**			-7.249***	-5.532***
			(2.03)	(2.43)			(1.18)	(0.94)
Level of growth rate				1.625				-7.105
				(6.32)				(4.65)
Volatility of growth rate				0.052				-0.028
				(0.09)				(0.06)
Wave 1999–2004	-0.187	-0.273	-0.246	-0.099	0.038	-0.052	-0.020	0.019
	(0.21)	(0.22)	(0.25)	(0.24)	(0.15)	(0.14)	(0.16)	(0.25)
Wave 2005–2007	-0.427***	-0.367***	-0.416***	-0.268	-0.483***	-0.418***	-0.474***	-0.247***
	(0.12)	(0.13)	(0.12)	(0.18)	(0.15)	(0.15)	(0.12)	(0.08)
Individual covariates	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	22,794	22,794	22,794	22,794	22,794	22,794	22,794	22,794
McFadden's pseudo R^2	0.0438	0.0445	0.0466	0.0470	0.0587	0.0597	0.0627	0.0642

(*Continued*)

Columns (9)–(12) present estimation results for confidence in parliament. Fiscal decentralization again enters with a positive and significant coefficient. The coefficient of government quality is never significant. Government size enters with a negative coefficient, but is only significant at the 10 percent level for the case in which we include all covariates at the aggregate level. Coefficients of income inequality, the macroeconomic performance indicators, and the 1999–2004 and 2005–2007 waves are similar in sign and significance as the coefficients in the case of confidence in civil services.

Columns (13)–(16) show that in all cases fiscal decentralization is positively related with confidence in political parties. The coefficients of government size, income inequality, and the 2005–2007 wave are always negative and significant. Government quality has a positive coefficient for the case in which we include all covariates at the aggregate level, but it is only significant at the 10 percent level. The remaining coefficients differ from the corresponding coefficients of the other measures of trust in government. More specifically, the 1999–2004 wave features a positive and significant coefficient, except for the case where we include all determinants at the aggregate level, and the macroeconomic performance indicators both show a negative and significant coefficient.

The overall picture suggests a positive and significant relationship of fiscal decentralization with trust in government. This relationship is robust to the inclusion of various control variables at the aggregate level. For those aggregate-level controls, the evidence is in line with the findings in the trust literature. Government quality is non-negatively related to trust in government and both government size and income inequality are negatively related. We do not find evidence of a systematic relationship between economic performance indicators at the aggregate level and trust in government. Although not shown here, the individual country dummies are jointly significant and we cannot reject the hypothesis that they should not be included in any of the specifications; see Table A.4 in the Appendix.

Table 2.2: Trust in Government and Fiscal Decentralization
Panel (a): Aggregate Level (Continued)

	Parliament				Political Parties			
	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Fiscal decentralization	3.834**	3.799**	4.901***	4.176***	3.921***	3.774***	4.578***	5.042***
	(1.51)	(1.49)	(0.98)	(1.29)	(1.13)	(0.90)	(0.68)	(0.63)
Government quality		-0.119	0.124	0.213		-0.218	-0.038	0.223*
		(0.35)	(0.26)	(0.28)		(0.23)	(0.17)	(0.13)
Government size		-0.547	-2.232	-3.392*		-3.242**	-4.514***	-7.665***
		(2.24)	(1.43)	(1.85)		(1.62)	(1.10)	(0.86)
Income inequality			-7.159***	-6.536***			-5.270***	-5.302***
			(1.26)	(1.44)			(1.02)	(0.76)
Level of growth rate				-3.455				-7.364***
				(3.55)				(1.85)
Volatility of growth rate				-0.022				-0.105***
				(0.06)				(0.03)
Wave 1999–2004	-0.099	-0.092	-0.062	-0.074	0.313***	0.308***	0.332***	0.116
	(0.10)	(0.11)	(0.13)	(0.16)	(0.08)	(0.07)	(0.10)	(0.08)
Wave 2005–2007	-0.403***	-0.407***	-0.466***	-0.393***	-0.269***	-0.265***	-0.306***	-0.399***
	(0.08)	(0.10)	(0.08)	(0.14)	(0.07)	(0.07)	(0.04)	(0.05)
Individual covariates	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	22,794	22,794	22,794	22,794	22,794	22,794	22,794	22,794
McFadden's pseudo R^2	0.0657	0.0658	0.0687	0.0689	0.0532	0.0540	0.0556	0.0562

Notes: The dependent variable is a measure of trust in government, that is, confidence in government, civil services, parliament or political parties. All equations are estimated by ordered logit. ***, **, and * denote significance at the 1, 5, and 10 percent level, respectively. Standard errors are reported in parentheses below the coefficients and are clustered at the country-wave level. All regressions include covariates at the individual level [panel (b) of Table 2] and country dummies (both are not reported).

2.4.1.2. Effects of Determinants at the Individual Level

Panel (b) of Table 2.2 focuses on the determinants at the individual level. To conserve on space, we restrict our attention to the estimation results corresponding to columns (4), (8), (12), and (16) of panel (a) of Table 2.2, where we include all determinants at the aggregate level. For all measures of trust in government, interpersonal trust enters with a positive and significant coefficient. The coefficient of gender is only significant for confidence in civil services and confidence in political parties, where it is negative and the base category is female. Coefficients of the 15–24 and 25–34 age categories are negative and significant, coefficients of the lower and middle education levels are positive and significant, and the base categories are age 35–44 and higher education.[17]

[17]Exceptions are the coefficients of middle education for confidence in civil services and age 15–24 for confidence in political parties, which are not significant.

Table 2.2: Trust in Government and Fiscal Decentralization
Panel (b): Individual level

	Government	Civil Services	Parliament	Political Parties
	(4)	(8)	(12)	(16)
Interpersonal trust	0.391***	0.338***	0.405***	0.302***
	(0.06)	(0.05)	(0.06)	(0.05)
Male	-0.014	-0.066***	0.014	-0.051*
	(0.03)	(0.02)	(0.03)	(0.03)
Age 15–24	-0.290***	-0.171***	-0.187***	-0.059
	(0.06)	(0.05)	(0.06)	(0.06)
Age 25–34	-0.194***	-0.144***	-0.166***	-0.095**
	(0.04)	(0.03)	(0.04)	(0.04)
Education is lower	0.336***	0.151*	0.236***	0.267***
	(0.08)	(0.08)	(0.07)	(0.07)
Education is middle	0.132**	0.025	0.118**	0.146***
	(0.06)	(0.05)	(0.05)	(0.05)
Income level 1	-0.285**	-0.171**	-0.189*	-0.060
	(0.12)	(0.07)	(0.11)	(0.09)
Income level 2	-0.240*	-0.071	-0.148	0.058
	(0.13)	(0.08)	(0.13)	(0.09)
Income level 3	-0.233**	-0.058	-0.137	-0.025
	(0.12)	(0.07)	(0.11)	(0.10)
Income level 4	-0.183*	-0.049	-0.119	0.022
	(0.10)	(0.08)	(0.10)	(0.08)
Social class is upper	0.187	0.195	0.147	0.004
	(0.17)	(0.17)	(0.14)	(0.19)
Social class is upper middle	0.409***	0.266***	0.362***	0.259**
	(0.12)	(0.10)	(0.12)	(0.11)
Social class is lower middle	0.272***	0.209***	0.201**	0.125
	(0.09)	(0.07)	(0.08)	(0.08)
Social class is working	0.166**	0.128**	0.079	0.055
	(0.07)	(0.06)	(0.07)	(0.07)
Politics is very important	0.577***	0.453***	0.688***	1.154***
	(0.06)	(0.05)	(0.06)	(0.09)
Politics is rather important	0.676***	0.479***	0.740***	1.021***
	(0.07)	(0.05)	(0.06)	(0.06)
Politics is not very important	0.490***	0.346***	0.508***	0.665***
	(0.05)	(0.04)	(0.05)	(0.05)
Aggregate covariates	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes
Observations	22,794	22,794	22,794	22,794
McFadden's pseudo R^2	0.0470	0.0642	0.0689	0.0562

Notes: The dependent variable is one of the four measures of trust in government, that is, confidence in government, civil services, parliament or political parties. All equations include covariates at the aggregate level [panel (a) of Table 2, columns (4), (8), (12), and (16), respectively]. The equations are estimated by ordered logit. ***, **, and * denote significance at the 1, 5, and 10 percent level, respectively. Standard errors are reported in parentheses below the coefficients and are clustered at the country-wave level. Base categories are female for gender, age 35–44, higher education, income level 10, social class is lower, and politics is not at all important in life. Coefficients of income levels 5 to 9 are never significant for any measure of trust in government and are not reported to conserve on space.

The estimation results for income level categories differ across the measures of trust in government, although all measures have in common that the coefficients of income levels 5 to 9 are not significant. Coefficients of income level categories are never significant for confidence in political parties. For the other measures of trust

in government, income level 1 has a negative and significant coefficient. Coefficients of income levels 2 to 4 are only significant for confidence in government and are negative. In all cases, income level 10 is the base category. Social class categories always enter with a positive coefficient for all measures of trust in government, where the base category is lower social class. However, these coefficients are never significant for the upper social class and always significant for the upper-middle social class. The significance of the coefficients of the other social class categories varies across the measures of trust in government. The categories measuring the importance of politics in life always show up with a positive and significant coefficient for all measures of trust in government, where the base category is that politics is not at all important in life.

In sum, the estimated coefficients of the determinants at the individual level are in line with the related literature, except for gender and education. Both interpersonal trust and income are positively related with trust in government, whereas gender and education have a negative relationship where a positive one is expected. The negative effect of education on trust in government may be explained by the inclusion of social class as a control variable, which is positively related to trust in government and positively associated with education.

2.4.1.3. Marginal Effects of Fiscal Decentralization

Because we use an ordered logit model, the sign of the estimated coefficients does not always correspond to the qualitative effect of fiscal decentralization on the reported confidence categories. More specifically, only the effects for the top and bottom categories are known; that is, a positive coefficient means that an increase in the fiscal decentralization ratio makes it more likely to have 'a great deal of confidence' and less likely to have 'none at all.' To determine the effects of fiscal decentralization on the intermediate categories of reported confidence, we calculate marginal effects, which are defined as the change in predicted probabilities of the categories of reported confidence for a one percentage point increase in the fiscal decentralization ratio.

Table 2.3 presents marginal effects at the mean, which we calculate based on the estimation results corresponding to columns (4), (8), (12), and (16) of Table 2.2.

Table 2.3: Marginal Effects at the Mean

Category	Marginal Effect	95 Percent Confidence Interval	S.E.	Marginal Effect	95 Percent Confidence Interval	S.E.
	Government			Civil Services		
A great deal	0.179	(0.024, 0.334)	0.079	0.091	(0.019, 0.163)	0.037
Quite a lot	0.781	(0.056, 1.507)	0.370	0.643	(0.216, 1.069)	0.218
Not very much	-0.317	(-0.630, -0.003)	0.160	-0.334	(-0.570, -0.098)	0.120
None at all	-0.644	(-1.215, -0.073)	0.291	-0.399	(-0.666, -0.133)	0.136
Confidence share[a]	1.342	(0.439, 2.246)	0.461	0.780	(0.202, 1.357)	0.295
	Parliament			Political Parties		
A great deal	0.118	(0.041, 0.195)	0.039	0.069	(0.044, 0.094)	0.013
Quite a lot	0.750	(0.279, 1.221)	0.240	0.633	(0.468, 0.798)	0.084
Not very much	-0.188	(-0.324, -0.053)	0.069	0.306	(0.223, 0.388)	0.042
None at all	-0.680	(-1.097, -0.262)	0.213	-1.008	(-1.245, -0.771)	0.121
Confidence share[a]	1.084	(0.533, 1.634)	0.281	0.632	(0.369, 0.894)	0.134

Notes: The table lists the marginal effects at the mean for a one percentage point change in the degree of fiscal decentralization. The marginal effects at the mean are calculated on basis of the estimation results corresponding to columns (4), (8), (12), and (16) of panel (a) of Table 2.2. The marginal effects at the mean for the category 'confidence share' indicated with superscript a are calculated on basis of the estimation results corresponding to columns (4), (8), (12), and (16) of Table B.4 in (Ligthart and Van Oudheusden, 2012b).

All marginal effects are significant and imply that a one percentage point increase in the degree of fiscal decentralization increases the confidence share on average by four-fifths of a percentage point. This effect is calculated by adding the marginal effects of the top two categories of confidence together for all measures of trust in government and subsequently taking the average. Moreover, it implies that a one standard deviation increase in fiscal decentralization increases trust in government with approximately half a standard deviation.[18]

The point estimate is the largest for confidence in government. These findings are confirmed when using a regular logit analysis on the confidence share directly—where the dependent variable takes the value one if the respondent indicates to have either 'a great deal of confidence' or 'quite a lot of confidence' and zero otherwise—although the estimated effect is somewhat larger; see Table 2.3.

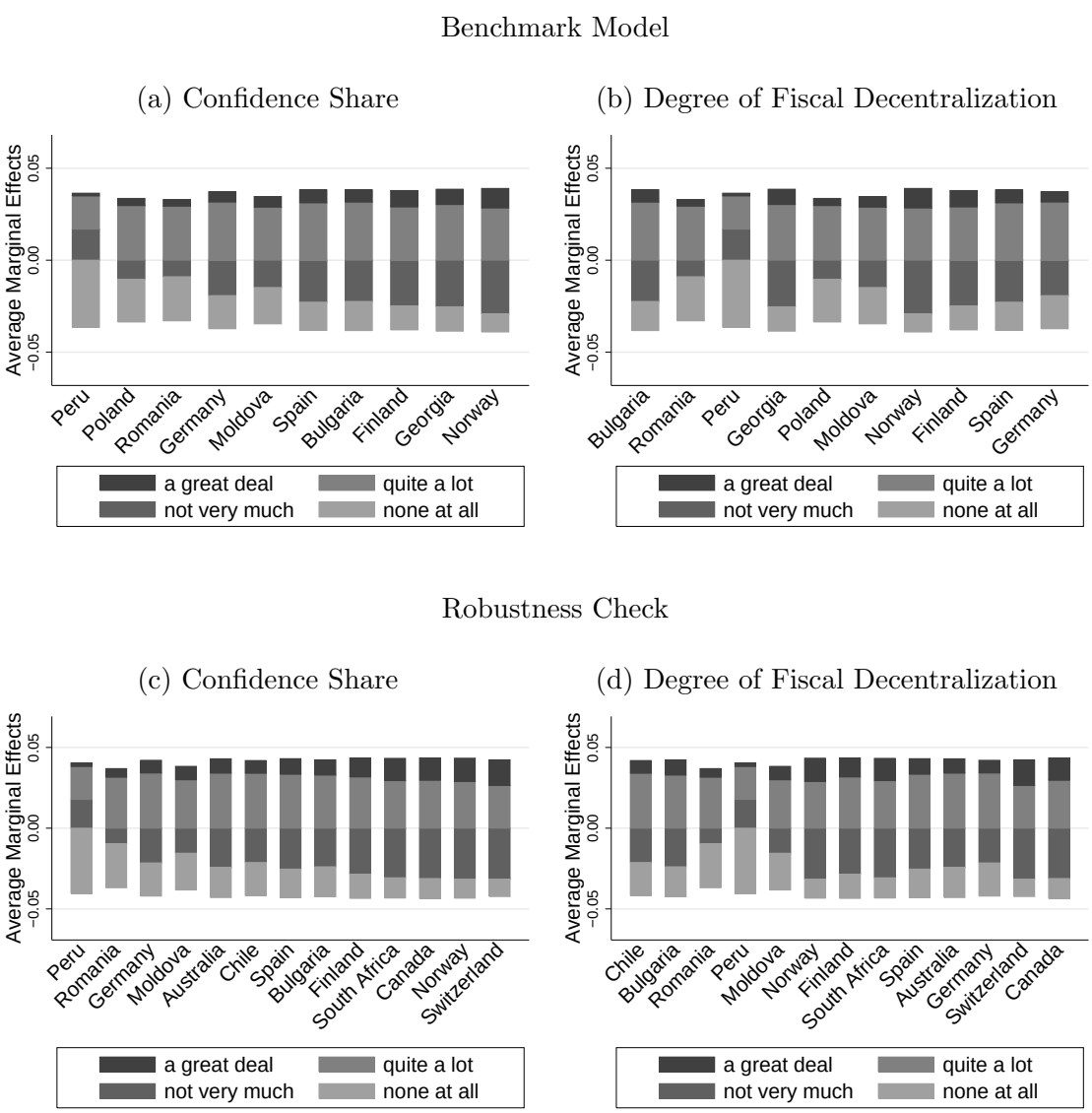
In nonlinear models, average behavior of individuals differs from the behavior of the average individual, yielding a difference between average marginal effects and marginal effects at the mean. By taking the average of the predicted probabilities across individuals in the sample, we derive average marginal effects rather than marginal effects at the mean. To facilitate a comparison of the results across countries, we calculate the average marginal effect for each country.

The results for an increase in the degree of fiscal decentralization by 5 percentage points are given in panels (a) and (b) of Figure 2.2, where the stacked bars are the changes in the average predicted probabilities for the respective confidence categories, which are represented by different shading patterns. The horizontal axis ranks countries in ascending order by either their confidence share or fiscal decentralization ratio.

The average marginal effects are the strongest for those countries with a large confidence share. When ranked by the degree of fiscal decentralization, we do not see a clear relationship. For example, Germany has a relatively high average fiscal decentralization ratio (39 percent) compared to Bulgaria (15 percent) or Georgia

[18]The standard deviation of fiscal decentralization is 0.09. A one standard deviation increase would lead to an increase in the confidence share of approximately $0.07 (= 0.09 \times 4/5)$. Since the average standard deviation of the confidence share for the several measures is 0.15, the 0.07 change corresponds to roughly half a standard deviation. This effect has to be interpret with some caution since it is based on average measures and ignores the non-linearity of the model.

Figure 2.2: Average Marginal Effects: Civil Services



Notes: The table presents average marginal effect which are defined as changes in the average predicted probabilities of the respective confidence categories for a 5 percentage points increase in fiscal decentralization. We focus on civil services because it has the largest number of significant variables. Panels (a) and (c) rank countries in ascending order by confidence share and panels (b) and (d) by the degree of fiscal decentralization. The average marginal effects in the panels (a) and (b) are calculated on basis of the estimation results corresponding to column (8) of Table 2.2. Those in panels (c) and (d) are calculated on basis of the estimation results corresponding to column (8) of Table B.5 of Ligthart and Van Oudheusden (2012b).

(20 percent), but has either a lower or the same average marginal effect on trust in government. However, these results do not imply that the overall effect of fiscal decentralization on trust is not representative for a given country. Rather, they suggest that the beneficial effect of fiscal decentralization on trust in government is neither limited to nor necessarily large for relatively decentralized countries.

2.4.2. Robustness Analyses

Next, we discuss several robustness checks. The corresponding estimation results can be found in Tables B.5 to B.8 in the Web Appendix to the chapter; see Ligthart and Van Oudheusden (2012b). As a first robustness check, we control for additional economic performance indicators at the individual level by including the individual's unemployment status to the set of covariates (cf. Brehm and Rahn, 1997; Mishler and Rose, 2001; Gustavsson and Jordahl, 2008). At the same time, we broaden the country coverage in the sample from 10 to 13—and thus work with the large sample—at the expense of losing income inequality as a control variable at the aggregate level (Table B.5).[19] The results are very similar to the benchmark outcomes. Fiscal decentralization always enters with a positive and significant coefficient. The only exception is for confidence in government, where the coefficient does not enter significantly once we control for the economic performance indicators at both the aggregate and individual level. The coefficients of government quality and government size are always positive and negative, respectively, but are only significant for confidence in civil services. These findings correspond to those of the benchmark outcome for government quality but deviate from the benchmark for government size. Thus, the negative relationship between government size and trust in government is only robust for confidence in civil services. As in panel (a) of Table 2.2, we do not find evidence of a systematic relationship between economic performance and trust in government, although some of the corresponding coefficients enter significantly. Moreover, the coefficient of individual unemployment is never significant.

To check the robustness of the average marginal effects, we calculate them us-

[19]The inclusion of unemployment at the individual level reduces the number of countries in the sample. To have at least as many countries as in our benchmark analysis, we drop inequality as a covariate. The large sample is also used for other robustness checks.

ing the estimation results for the large sample.[20] Panels (c) and (d) of Figure 2.2 show results similar to those in the benchmark case, which suggest that the size of the beneficial effect of fiscal decentralization on trust in government is not necessarily larger for more centralized countries. For example, Bulgaria and Chile have a relatively low average degree of fiscal decentralization compared to Australia and Germany, but have rather similar marginal effects. Finally, we find that, on average, the quantitative effect is smaller when looking at the point estimates. A one percentage point increase in fiscal decentralization now causes roughly a two-thirds of a percentage point increase in the confidence share.

As a second robustness check, we increase the sample size so that it includes 36 countries. However, this procedure comes at a cost since we only can take up fiscal decentralization as a variable at the aggregate level and cannot include country dummies in our specifications (Table B.6). The results are broadly consistent across the different samples; the pooled sample of 36 countries, the large sample, and the small sample. Fiscal decentralization enters with a positive coefficient and is significant in most of the cases. The exceptions are for confidence in government and, for the small sample, confidence in parliament and political parties. Although we cannot control for unobserved country heterogeneity and possible indirect effects such as government quality, these results suggest that our results are not specific to a small set of countries.

As final robustness checks, we repeat the analyses of Table 2.2, where we either replace our expenditure-based fiscal decentralization measure by one that is based on revenues (Table B.7), or replace our measure of government quality by a measure of corruption control (Table B.8).[21] When we use the share of sub-national revenue in general government revenues as our measure of fiscal decentralization its coefficient always enter positively. However, it is not always significant in cases where we do not control for the possible determinants at the aggregate level such as income inequality. Control of corruption always enters with a positive coefficient but is only

[20]The average marginal effects of the three other measures of trust in government and the marginal effects at the mean for all four measures are available upon request.

[21]Our measure of corruption control is taken from the World Bank's *Worldwide Governance Indicators* (2008) and has a similar structure to our measure of government quality. Hence, we expect it to be positively related with trust in government.

significant for confidence in civil services. In all cases, fiscal decentralization enters with a positive and significant coefficient.[22]

Table 2.4 presents results where we control for the potential reverse causality of fiscal decentralization. The even numbered columns of panel (a) regress the measures of trust in government on the lag of fiscal decentralization, and the same set of variables as in Table 2.2 except income inequality. The odd numbered columns—which employ the contemporaneous value of fiscal decentralization—serve as a comparison. All estimations include country dummies and wave dummies. Across all measures of trust in government, fiscal decentralization shows a positive and significant coefficient. Except for government size, the other effects are similar to those of the benchmark analysis.

Panel (b) of Table 2.4 reports the results of the other approach. The even numbered columns regress the respective measure of trust in government on the lag of fiscal decentralization, the contemporaneous values of gender and age, and country and wave dummies. Subsequently, the off numbered columns add the lag of government size and the lag of the economic performance indicators. We exclude government quality from the analysis, since data from the *Worldwide Governance Indicators* are only available from 1996 onward. The results are similar to previous findings. Fiscal decentralization increases trust in government once we control for covariates at the aggregate level. Government size enters with a significant and negative coefficient. We do not find a systematic relationship between economic performance and trust in government.

[22]We also perform an ordered probit analysis of our benchmark analyses. The results are the same in sign and significance as those of the ordered logit model and are therefore not reported. To check for the robustness of our result to the choice of trust in government measures, we take the average of the four measures of trust in government together as a new dependent variable. Although the qualitative results in this case remain the same, we cannot say anything about the quantitative effects. Averaging our trust in government measures increases the number of confidence categories from four to 13. More precisely, the resulting average trust in government measure takes the values 1, 1.25, 1.50,...,3.50, 3.75, and 4. These new confidence categories, however, have no meaning.

Table 2.4: Trust in Government and Fiscal Decentralization: Controlling for Endogeneity
Panel (a): Approach I

	Government		Civil Services		Parliament		Political Parties	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Fiscal decentralization	6.294***	6.045***	3.278***	2.667***	4.992***	4.491***	4.302***	3.683***
	(0.85)	(0.76)	(1.04)	(0.96)	(1.02)	(0.96)	(0.97)	(0.93)
Government quality	1.418***	1.507***	0.869***	0.875***	0.515*	0.561*	0.391	0.414
	(0.20)	(0.22)	(0.21)	(0.23)	(0.27)	(0.29)	(0.25)	(0.27)
Government size	22.624***	18.067***	1.924	-0.095	14.630**	11.251*	12.905***	10.164**
	(4.92)	(5.72)	(4.42)	(4.56)	(6.16)	(6.59)	(4.62)	(4.90)
Level of growth rate	-2.165	-1.548	-8.014***	-7.503***	-4.065	-3.469	-9.078***	-8.488***
	(3.27)	(2.94)	(2.45)	(2.52)	(3.28)	(3.12)	(2.35)	(2.28)
Volatility of growth rate	0.404***	0.384***	0.044	0.033	0.229***	0.213***	0.053	0.039
	(0.04)	(0.05)	(0.04)	(0.04)	(0.06)	(0.06)	(0.05)	(0.05)
Unemployment	0.097	0.095	0.013	0.012	0.106	0.105	0.022	0.021
	(0.09)	(0.09)	(0.06)	(0.06)	(0.11)	(0.11)	(0.07)	(0.07)
Wave 1999–2004	-0.127	0.014	-0.167*	-0.085	-0.159	-0.043	-0.009	0.095
	(0.12)	(0.11)	(0.10)	(0.10)	(0.12)	(0.12)	(0.09)	(0.09)
Wave 2005–2007	0.523***	0.533***	0.033	0.049	0.204**	0.219**	0.053	0.069
	(0.07)	(0.08)	(0.10)	(0.11)	(0.10)	(0.10)	(0.08)	(0.09)
Individual covariates	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lagged fiscal decentralization	No	Yes	No	Yes	No	Yes	No	Yes
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	30,842	30,842	30,842	30,842	30,842	30,842	30,842	30,842
McFadden's pseudo R^2	0.0651	0.0651	0.0554	0.0552	0.0801	0.0799	0.0707	0.0705

(*Continued*)

Table 2.4: Trust in Government and Fiscal Decentralization: Controlling for Endogeneity (Continued)
Panel (b): Approach II

	Government		Civil Services		Parliament		Political Parties	
	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Fiscal decentralization (lagged)	3.044*	1.745	0.937	1.764**	2.867	3.281**	2.913**	3.984***
	(1.76)	(1.77)	(1.04)	(0.76)	(1.77)	(1.54)	(1.30)	(1.31)
Government size (lagged)		-34.144***		-16.636***		-17.341***		-6.730
		(8.66)		(3.09)		(6.30)		(5.89)
Level of growth rate (lagged)		-6.341*		4.340***		-1.673		2.278
		(3.30)		(1.60)		(3.09)		(2.71)
Volatility of growth rate (lagged)		0.123**		0.284***		0.170***		0.179***
		(0.06)		(0.03)		(0.04)		(0.05)
Male	-0.001	-0.000	-0.050***	-0.051	0.050	-0.055	-0.004	-0.003
	(0.03)	(0.03)	(0.02)	(0.06)	(0.03)	(0.07)	(0.02)	(0.02)
Age 15–24	-0.141*	-0.131*	-0.055	-0.115***	-0.057	-0.091**	-0.056	-0.055
	(0.08)	(0.08)	(0.06)	(0.03)	(0.07)	(0.05)	(0.05)	(0.05)
Age 25–34	-0.117**	-0.108**	-0.116***	0.037	-0.093**	-0.006	-0.089**	-0.089**
	(0.05)	(0.05)	(0.03)	(0.06)	(0.05)	(0.17)	(0.04)	(0.04)
Wave 1999–2004	-0.010	0.041	0.057	0.225***	-0.044	0.118	0.183	0.186
	(0.22)	(0.20)	(0.11)	(0.06)	(0.16)	(0.11)	(0.15)	(0.14)
Wave 2005–2007	-0.012	0.165	-0.005	-0.048***	-0.090	0.050	-0.041	0.132
	(0.17)	(0.16)	(0.11)	(0.02)	(0.12)	(0.03)	(0.09)	(0.10)
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	30,842	30,842	30,842	30,842	30,842	30,842	30,842	30,842
McFadden's pseudo R^2	0.0410	0.0449	0.0449	0.0484	0.0543	0.0562	0.0331	0.0344

Notes: The dependent variable is a measure of trust in government. ***, **, and * denote significance at the 1, 5, and 10 percent level, respectively. Standard errors are reported in parentheses below the coefficients and are clustered at the country-wave level. All regressions include covariates at the individual level and country dummies (both are not reported). Lags of aggregate variables are based on the three years preceding the starting year of the waves, that is, the years 1991–1993, 1996–1998, and 2002–2004 for the 1994–1998, 1999–2004, and 2005–2007 wave, respectively. The reduction in sample size is caused by Moldova and the 1994–1998 wave of South Africa for which no lagged fiscal decentralization data are available. The even numbered columns of panel (a) lag fiscal decentralization, whereas the odd numbered columns—as a comparison—use the contemporaneous value of fiscal decentralization. The even numbered columns of panel (b) use lagged fiscal decentralization, age, and gender. The odd numbered columns of panel (b) add lags of all variables at the aggregate level. Government quality is excluded as a covariate because data are only available from 1996 onward.

2.5. Conclusions

The chapter analyzes whether fiscal decentralization enhances trust in government. To this end, we use survey data on several measures of trust in government (i.e., government, civil services, parliament, and political parties) for up to 13 countries over the period 1994–2007. In addition to fiscal decentralization, we include macroeconomic determinants like government quality, government size, inequality, macroeconomic performance indicators, and individual characteristics as determinants of trust in government. We also control for unobserved country heterogeneity and common shocks over time.

We find that fiscal decentralization increases trust in government above and beyond interpersonal trust. More specifically, a one standard deviation increase in the fiscal decentralization ratio causes roughly half a standard deviation increase in trust in government. The beneficial effect of fiscal decentralization on trust in government is neither limited to nor necessarily large for relatively decentralized countries. Our findings are robust to different sample sizes, changes in the set of control variables, and estimation techniques.

Our results are important from a policy point of view. Policy recommendations on fiscal decentralization have typically been based on the perceived improvements in allocative efficiency. Recognizing the improvements in trust in government would help policy makers in forming a more complete assessment of the pros and cons of fiscal decentralization. More important, trust in government contributes to the credibility and success of government policy more generally.

Future research could usefully focus on providing a theoretical underpinning of the transmission channels of fiscal decentralization on trust in government. Another avenue for further research is a more thorough treatment of the potential endogeneity of fiscal decentralization. To this end, we need to aggregate the confidence categories to just two and have to find valid instruments for fiscal decentralization. Because we control for country fixed effects—and thus exploit the within dimension of variation—suitable instruments have to be time varying. In this way, we can resort to a probit analysis with instrumental variables. Finally, an analysis of

the relationship between fiscal decentralization and trust in government in a setting where better measures for these concepts are available would further enhance our understanding of the possible trust benefits of fiscal decentralization.

Appendix 2.A

Table A.1: Trimming Procedures

Procedure	Observations	Countries
Small Sample		
World Values Survey dataset[a]	257,597	87
Conditioning on dependent variables	183,828	80
Conditioning on determinants at the individual level	132,983	74
Conditioning on fiscal decentralization[b]	67108	36
Conditioning on remaining aggregate level determinants	28,837	17
Conditioning on non-singletons	22,794	10
Small sample	22,794	10
Large Sample		
World Values Survey dataset[a]	257,597	87
Conditioning on dependent variables	183,828	80
Conditioning on individual unemployment	177,820	80
Conditioning on remaining individual level determinants	128,868	74
Conditioning on fiscal decentralization[b]	63,566	35
Conditioning on remaining aggregate level determinants	43,043	22
Conditioning on non-singletons	35,259	13
Large sample	35,259	13
Conditioning on lags	30,842	12

Notes: The dependent variables are the following measures of government trust: confidence in government, confidence in civil services, confidence in parliament, and confidence in political parties. Determinants at the individual level are interpersonal trust, age, education, social class, income levels, and the importance of politics in life, except noted otherwise. Determinants at the aggregate level are fiscal decentralization, government quality, government size, the level and volatility of the growth rate, and, for the small sample, income inequality. [a]Based on the World Values Survey 2009 dataset. [b]Table B.3 in (Ligthart and Van Oudheusden, 2012b) provides coverage of the fiscal decentralization measure.

Table A.2: Country Shares in the Small and Large Sample

Country	Decentralization Ratio	Small Sample					Large Sample				
		Time Period			Total	Percent	Time Period			Total	Percent
		1994–1998	1999–2004	2005–2007			1994–1998	1999–2004	2005–2007		
Australia[a,b]	0.39						1,605		1,210	2,815	7.98
Bulgaria	0.15	576		709	1,285	5.64	576		709	1,285	3.64
Canada[a,b]	0.59							1,516	1,514	3,030	8.59
Chile	0.13						827	1,035	851	2,713	7.69
Finland[a]	0.33	768		861	1,629	7.15	768		861	1,629	4.62
Georgia	0.20	1,727		1,121	2,848	12.49					
Germany[a,b]	0.39	1,376		1,594	2,970	13.03	1,366		1,587	2,953	8.38
Moldova	0.23	811	758	933	2,502	10.98	811	758	933	2,502	7.1
Norway[a]	0.30	939		883	1,822	7.99	939		883	1,822	5.17
Peru	0.19	842	1,400	1,230	3,472	15.23	842	1,400	1,228	3,470	9.84
Poland[a]	0.21	772		711	1,483	6.51					
Romania	0.17	975		1,309	2,284	10.02	975		1,301	2,276	6.46
South Africa	0.37						1,915	2,135	2,504	6,554	18.59
Spain[a,b]	0.37	743	767	989	2,499	10.96	743	765	989	2,497	7.08
Switzerland[a,b]	0.49						761		952	1,713	4.86
Total		9,529	2,925	10,340	22,794	100.00	12,128	7,609	15,522	35,259	100.00

Notes: We use the small sample for the benchmark specification and the large sample for the robustness checks. Table 2.1 and Figure 2.1 are based on the large sample. Countries marked with the superscript *a* are OECD members during the sample period and those marked by the superscript *b* are federal countries. Since our sample does not contain countries where interviews took place in 1999, the first time period corresponds to the wave 1994–1999 of the *World Values Survey* 2009. The decentralization ratio of a country is based on the sample average for the respective country.

Table A.3: Descriptive Statistics of the Benchmark Sample

	Obs	Mean	St. Dev.	Min	Max	Source
Confidence in government	22,794	2.20	0.82	1	4	WVS
Confidence in civil services	22,794	2.23	0.77	1	4	WVS
Confidence in parliament	22,794	2.12	0.81	1	4	WVS
Confidence in political parties	22,794	1.90	0.73	1	4	WVS
Interpersonal trust	22,794	0.27	0.44	0	1	WVS
Male	22,794	0.49	0.50	0	1	WVS
Age 15-24	22,794	0.25	0.43	0	1	WVS
Age 25-34	22,794	0.40	0.49	0	1	WVS
Age 35-44	22,794	0.35	0.48	0	1	WVS
Education is lower	22,794	0.31	0.46	0	1	WVS
Education is middle	22,794	0.47	0.50	0	1	WVS
Education is upper	22,794	0.23	0.42	0	1	WVS
Income level 1	22,794	0.13	0.33	0	1	WVS
Income level 2	22,794	0.16	0.37	0	1	WVS
Income level 3	22,794	0.17	0.37	0	1	WVS
Income level 4	22,794	0.15	0.36	0	1	WVS
Income level 5	22,794	0.14	0.35	0	1	WVS
Income level 6	22,794	0.09	0.29	0	1	WVS
Income level 7	22,794	0.07	0.25	0	1	WVS
Income level 8	22,794	0.05	0.21	0	1	WVS
Income level 9	22,794	0.02	0.15	0	1	WVS
Income level 10	22,794	0.02	0.16	0	1	WVS
Social class is upper	22,794	0.01	0.11	0	1	WVS
Social class is upper middle	22,794	0.17	0.37	0	1	WVS
Social class is lower middle	22,794	0.39	0.49	0	1	WVS
Social class is working	22,794	0.34	0.47	0	1	WVS
Social class is lower	22,794	0.09	0.29	0	1	WVS
Politics is very important	22,794	0.10	0.30	0	1	WVS
Politics is rather important	22,794	0.27	0.45	0	1	WVS
Politics is not very important	22,794	0.39	0.49	0	1	WVS
Politics is not at all important	22,794	0.24	0.43	0	1	WVS
Fiscal decentralization	22,794	0.25	0.09	0.11	0.44	GFS
Government quality	22,794	0.58	1.08	-0.79	2.14	WGI
Government size	22,794	0.17	0.04	0.10	0.23	WDI
Income inequality	22,794	0.36	0.08	0.26	0.52	WIIDER
Level of growth rate	22,794	0.04	0.04	-0.09	0.11	WDI
Volatility of growth rate	22,794	2.85	3.62	0.10	15.84	WDI

Notes: Based on the small sample (which is our benchmark). Data sources are the *World Values Survey* (WVS), the IMF's *Government Finance Statistics* (GFS), the World Bank's *Worldwide Governance Indicators* (WGI), the World Bank's *World Development Indicators* (WDI), and Version 2.0c of the *World Income Inequality Database* (WIIDER) of the World Institute for Development Economics Research. Descriptive statistics of variables at the aggregate level are calculated on a country-wave basis. The variable volatility of the growth rate is multiplied by a factor 100.

Table A.4: Trust in Government and Fiscal Decentralization: Testing for Country Fixed Effects

	Government		Civil Services		Parliament		Political Parties	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Fiscal decentralization	-0.733	2.632	0.590	3.584***	0.175	3.018**	0.346	3.098***
	(0.92)	(1.65)	(0.71)	(1.26)	(0.88)	(1.35)	(0.61)	(1.19)
Government quality	0.133	0.601	0.256*	0.941***	0.035	0.097	-0.054	0.141
	(0.21)	(0.39)	(0.14)	(0.25)	(0.17)	(0.25)	(0.12)	(0.20)
Government size	2.516	-9.358	4.766*	-11.698**	7.370**	-6.450	5.467**	-6.179
	(3.54)	(7.06)	(2.75)	(5.03)	(3.20)	(5.43)	(2.29)	(4.35)
Level of growth rate	-3.597	2.349	-2.857	-4.961**	-5.853	-1.194	-5.947	-6.062**
	(6.02)	(4.47)	(5.71)	(2.49)	(5.36)	(3.23)	(4.20)	(2.39)
Volatility of growth rate	-0.011	0.120**	0.042	0.037	-0.057	0.058	-0.087*	-0.063**
	(0.08)	(0.06)	(0.06)	(0.04)	(0.07)	(0.04)	(0.05)	(0.03)
Unemployment	0.232**	0.119	0.129*	0.043	0.195*	0.127	0.106	0.060
	(0.11)	(0.07)	(0.07)	(0.05)	(0.11)	(0.09)	(0.07)	(0.06)
Wave 1999–2004	0.184	-0.079	0.123	-0.076	0.043	-0.135	0.200	0.019
	(0.32)	(0.15)	(0.20)	(0.09)	(0.27)	(0.13)	(0.20)	(0.10)
Wave 2005–2007	0.095	0.133	0.053	-0.033	-0.067	-0.038	-0.081	-0.141*
	(0.35)	(0.11)	(0.20)	(0.10)	(0.30)	(0.10)	(0.21)	(0.08)
Individual covariates	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country dummies	No	Yes	No	Yes	No	Yes	No	Yes
Observations	35,259	35,259	35,259	35,259	35,259	35,259	35,259	35,259
McFadden's pseudo R^2	0.0208	0.0581	0.0352	0.0532	0.0455	0.0753	0.0536	0.0688

Notes: The dependent variable is a measure of trust in government. All equations are estimated by ordered logit. ***, **, and * denote significance at the 1, 5, and 10 percent level, respectively. Standard errors are reported in parentheses below the coefficients and are clustered at the country-wave level. All regressions include covariates at the individual level (which are not reported). The results presented in columns (2), (4), (6), and (8) coincide with those in columns (4), (8), (12), and (16) of Table 4. Wald tests on the country dummies for columns (2), (4), (6), and (8) give χ^2 values of 394.91, 241.88, 332.49, and 446.56, respectively, where the critical value is 5.23.

3

The Fiscal Decentralization and Economic Growth Nexus Revisited[1]

3.1. Introduction

Many developed and developing countries have devolved parts of their fiscal policy-making authority to sub-national levels of government during the last decades. This process of fiscal decentralization has led to a wide array of empirical analyses that look at its possible consequences, where the relationship between fiscal decentralization and economic growth has received the most attention. Despite this attention, there is no consensus on this relationship, which may be explained by differences in empirical specifications, country coverage and time period of the samples, or econometric methods used. Only little attention has been paid to possible endogeneity problems that may plague the relationship between fiscal decentralization and economic growth. This concern, however, is of relevance regardless of any characteristics that sets these analyses apart. Moreover, disagreement on the accuracy with which conventional government revenue and expenditure based measures of fiscal decentralization reflect the autonomy of sub-national governments has led to the use of alternative measures of fiscal decentralization. A consensus of what the effect of doing so is compared to the use of conventional measures is absent though. This chapter revisits the relationship between fiscal decentralization and economic growth and addresses both of the above issues.

[1]This chapter is based on Ligthart and Van Oudheusden (2012a).

The main argument in favor of fiscal decentralization can be derived from the principle of subsidiarity as discussed by Tiebout (1956) and Oates (1972, 1999). They reason that the proximity of sub-national governments to households gives them an information advantage over national governments about local preferences, resulting in an improvement of allocative efficiency in the public sector. This efficiency gain in turn translates in a higher growth rate. A higher growth rate, however, leads to a higher income which in turn may affect fiscal decentralization (cf. Panizza, 1999).[2] To deal with this problem of reverse causality, we construct new instrumental variables for fiscal decentralization based on common legal system origin, common federal system, geographical distance, and relative country size. We argue that countries similar in these aspects experience a similar process of fiscal decentralization. Other papers that look at instrumental variables for fiscal decentralization are Fisman and Gatti (2002), Iimi (2005), and Enikolopov and Zhuravskaya (2007). In contrast to their instrumental variables, ours vary over time, do not lead to a reduction in the sample size, and can be tested for correlation with the error terms. To our knowledge, we are the first to use these instrumental variables and compare them with the conventional instruments in the literature.

Most of the literature uses fiscal decentralization measures based on government expenditures and revenue data from the *Government Finance Statistics* of the International Monetary Fund. Martinez-Vazquez and McNab (2003) argue that these measures may not capture all dimensions of fiscal decentralization such as the degree of discretion that sub-national governments have over expenditures and taxes. We use data on the tax autonomy of sub-national governments provided by the OECD (1999, 2006, 2009) to capture this dimension. Papers that have a similar approach are Ebel and Yilmaz (2002) and Thornton (2007).[3] We contribute to the literature in this aspect by addressing methodological issues, which enables us to clearly identify whether results change with the use of alternative measures.

[2]See Martinez-Vazquez and McNab (2003) and references therein for a detailed review of the channels and issues concerning the relationship between fiscal decentralization and economic growth. More formal models that describe the effect of fiscal decentralization on economic growth are discussed later on.

[3]Bodman and Ford (2006) and Baskaran and Feld (2009) use alternative measures of fiscal decentralization based on Stegarescu (2005) to capture the dimension of policy-making authority of sub-national governments.

Using a sample of 56 countries over the period 1990–2007, we find that fiscal decentralization is beneficial for economic growth. A one standard deviation in fiscal decentralization leads to an increase in economic growth of on average a half percentage point. Our proposed instruments outperform the conventional external instruments in the literature, where instruments based on legal origin and relative country size are our preferred instruments. Although internal instruments—i.e., the lag of the fiscal decentralization measure itself—can be used, they have the disadvantage that the accompanied reduction in the sample leads to selection bias. When controlling for unobserved country heterogeneity, we find an inverted u-shaped relationship between fiscal decentralization and economic growth.

The use of various measures of fiscal decentralization that differ in the degree in which they reflect the discretion of sub-national governments may change the results. These changes, however, are the result of the accompanied changes in the samples rather than the use of the alternative measures themselves. Hence, conventional measures are a good approximation for measures that better reflect the true degree of fiscal autonomy of sub-national governments. Finally, the effect of fiscal decentralization on economic growth holds both in the short and long run, is robust to the use of alternative measures of fiscal decentralization based on revenue and expenditure data, and seems more appropriate for OECD member countries than other countries.

The remainder of this chapter is organized as follows. Section 2 presents an overview of the theoretical and empirical literature. Section 3 discusses our econometric specification, data, endogeneity issues, and various measures of fiscal decentralization. Section 4 presents the results. Section 5 concludes.

3.2. Literature

This section provides a short overview of the theoretical and empirical literature on the relationship between fiscal decentralization and economic growth. Since there are already good overviews of the more informal theoretical literature (i.e.,

Martinez-Vazquez and McNab, 2003; Rodríquez-Pose and Ezcurra, 2010), we focus on the literature that uses formal, mathematical models to explain the relationship between fiscal decentralization and economic growth. When discussing the empirical literature, we limit attention to those analyses that look at the relationship in a cross-country context.

3.2.1. Theoretical Literature

The literature that provides theoretical underpinnings for the effect of fiscal decentralization on economic growth is almost absent. Moreover, the literature that does provide a formal framework in which this relationship is analyzed focuses on other mechanisms than the subsidiarity principle as discussed by Tiebout (1956) and Oates (1972, 1999). The mechanism that is used most often for empirical analyses builds on the framework of Barro (1990) and is provided by Davoodi and Zou (1998). In their model, output is affected by government expenditures at both the national and sub-national level. Under the additional assumption that government expenditures at both levels are subject to diminishing returns to scale, it is optimal to devolve part of total government expenditures to the sub-national level.[4] The framework is also used to analyze optimal taxation and intergovernmental transfers issues (Gong and Zou, 2002).

Another approach is taken by Lejour and Verbon (1997), Hatfield (2006), and Koethenbuerger and Lockwood (2010), who look at intergovernmental relations between sub-national governments themselves rather than between different levels of government.[5] Tax competition between sub-national governments leads to lower taxes compared to a fully centralized government, which in turn stimulates economic growth. This downward effect on taxes may be mitigated or even reversed in the presence of mobility costs of capital (Lejour and Verbon, 1997) or stochastic productivity shocks (Koethenbuerger and Lockwood, 2010). Fiscal decentralization then leads to a reduction in economic growth.

[4]This result extends to multiple levels of government expenditures and is independent of their degree of substitutability (Xie et al., 1999).

[5]More specifically, Lejour and Verbon (1997) look at coordination issues between countries but their mechanism extends to sub-national governments as well. See Koethenbuerger and Lockwood (2010) for an extensive overview of the related literature.

The mechanism as described by Brueckner (1999, 2006) is more in line with the subsidiarity principle. In a framework with overlapping generations he compares a situation of full centralization, where the young and old receive the same level of public goods, to a situation of full decentralization, where the provision of public goods is tailored to their preferences. Depending on the production structure, a switch from a fully centralized to a fully decentralized government either has transitory (Brueckner, 1999) or permanent (Brueckner, 2006) growth effects.[6] Although these analyses focus on intertemporal preference differences and abstract from a government that is partly decentralized, they capture the idea that preference matching may foster economic growth.

3.2.2. Empirical Literature

Table 3.1 gives an overview of cross-country studies on the relationship between fiscal decentralization and economic growth. Rather than discussing the individual papers extensively, we sketch a broad overview of the findings in the literature; see Rodríquez-Pose and Ezcurra (2010) and Buser (2011) for recent discussions and critical assessments of individual papers. From Table 3.1 it becomes clear there is no general consensus on the effect of fiscal decentralization on economic growth. There are almost as many analyses that find a positive, a negative, or no relationship. Moreover, these results cannot be explained by looking at differences in the number or type of countries, the time period of the analysis, or estimation method used. These findings suggest that differences in empirical specifications and data used are a better explanation.

What is puzzling though is that only some analyses address the issue of possible endogeneity problems. This concern, however, is of relevance regardless of the specification, data, country composition of the sample or time period considered. Analyses that do deal with this issue have in common that they either have a relative large number of observations (Martinez-Vazquez and McNab, 2006) or focus solely on the cross-sectional variation in the data (Iimi, 2005; Enikolopov and Zhuravskaya, 2007). They differ in the use of either internal or external instruments

[6] Actually, these results are driven by differentiation of taxes for the young and old, which work in the opposite direction of the provision of public goods.

Table 3.1: Overview of Fiscal Decentralization and Economic Growth Literature

Paper	Direct Effect	Countries	Time Period	Methods	Countries	Endogeneity	Autonomy
Woller and Phillips (1998)	None	23	1974–1991	Panel	D	No	No
Davoodi and Zou (1998)	Negative	46	1970–1989	Panel	D + I	No	No
Castles (1999)	None	21	1960–1992	OLS	I	No	No
Ebel and Yilmaz (2002)	Positive	6	1997–1999	Panel	D	No	Yes
Thiessen (2003)	Positive	25	1973–1998	OLS	I	No	No
Iimi (2005)	Positive	51	1992–2001	OLS	D + I	Yes, Internal	No
Martinez-Vazquez and McNab (2006)	Negative	66	1972–2003	Panel	D + I	Yes, Internal	No
Bodman and Ford (2006)	None	18	1981–1998	Both	I	No	Yes
Enikolopov and Zhuravskaya (2007)	None	75	1975–2000	OLS	D	Yes, External	No
Thornton (2007)	None	19	1980–2000	OLS	I	No	Yes
Baskaran and Feld (2009)	None	23	1975–2001	Both	I	No	Yes
Rodríquez-Pose and Kroijer (2009)	Negative	16	1990–2004	Panel	D	No	No
Rodríquez-Pose and Ezcurra (2010)	Negative	21	1990–2005	OLS	I	No	No
Buser (2011)	Positive	20	1972–2005	Panel	I	No	No

Notes: The table focuses on the direct effect and abstracts from any interaction effects. "Panel" refers to analyses that allow for country fixed effects and "OLS" to analyses that do not, even though they may have a panel structure. Developing countries are indicated with "D" and industrialized countries with "I". Correction for autonomy is based on the use of OECD (1999, 2006, 2009) data or Stegarescu (2005) data.

though. In general, a thorough analysis of the endogeneity problems concerning the relationship between fiscal decentralization and economic growth seems to be missing.

In addition, little attention is being paid to the quantitative effect of fiscal decentralization on economic growth. Most analyses focus on the sign and significance of the fiscal decentralization coefficient, a possible non-linear effect, or how the effect depends on the interaction with other explanatory variables. This focus makes it hard to judge whether their findings are plausible or are of economic relevance. There is, however, a common understanding that conventional fiscal decentralization measures solely based on expenditure or revenue data may overestimate the degree of true fiscal policy making authority of sub-national governments (Martinez-Vazquez and McNab, 2003). Although some analyses use autonomy corrected fiscal decentralization measures, there is no consensus of what the effect of doing so is compared to the use of conventional measures of fiscal decentralization.

3.3. Empirical Methodology and Data

This section discusses the econometric specification, endogeneity issues, and several measures of fiscal decentralization. We use data of 56 countries over the period 1990–2007, where variables are three year averages unless indicated otherwise. Descriptive statistics, the corresponding data sources, and sample composition are given in Tables A.1–A.3 in the Appendix.

3.3.1. Econometric Specification

We follow the literature on fiscal decentralization and economic growth, and use a "Barro-style" growth regression:

$$g_{it} = \phi f_{it} + \beta \ln y_{i0} + \boldsymbol{\psi}' \mathbf{x}_{it} + \boldsymbol{\gamma}' \mathbf{z}_{it} + \varepsilon_{it}, \tag{3.1}$$

where countries are denoted with $i = 1, ..., N$ and time with $t = 1, ..., T$. The dependent variable g_{it} denotes the growth rate of real GDP per capita of country i at time

t. Our variable of interest—the degree of fiscal decentralization—is denoted by f_{it}, and $\ln y_{i0}$ is the logarithm of the initial value of real GDP per capita, where β and ϕ are the corresponding parameters, respectively. The matrix $\mathbf{x}_{it}$ contains explanatory variables associated with the augmented Solow model as described by Mankiw et al. (1992), and $\mathbf{z}_{it}$ is a matrix of additional explanatory variables (see below), where $\boldsymbol{\psi}$ and $\boldsymbol{\gamma}$ are the corresponding vectors of parameters, respectively. We define $\varepsilon_{it} \equiv \mu_i + \eta_t + \epsilon_{it}$, where μ_i is a country-specific fixed effect, η_t is a time fixed effect, and ϵ_{it} is an independent and identically distributed error term. Depending on the specification we consider, the country-specific and time fixed effects may be set to zero or not.

In line with most of the fiscal federalism literature, we define our benchmark measure of fiscal decentralization as the share of sub-national government expenditures in general government expenditures. Sub-national expenditures are defined as expenditures at both the state and local government level, where the state level refers to the largest geopolitical entity within a country and the local level describes the smaller governmental units below the state level; see the IMF's *GFS Manual* (2001).[7] General government expenditures encompass public expenditures at the central, state, and local government level together.

The set of augmented Solow variables $\mathbf{x}_{it}$ consists of population growth, investment, and schooling. Population growth is measured as in Mankiw et al. (1992), which is the logarithm of the the sum of the capital depreciation rate, the rate of technological progress, and the population growth rate. Investment is measured by the logarithm of the share of gross fixed capital information in output, and schooling is defined as the logarithm of the product of gross secondary school enrollment and the population share of secondary school age.

The matrix $\mathbf{z}_{it}$ contains additional controls such as a the federal system, government size, trade openness, and regional dummies. The federal system is represented by a dummy that takes on the value one if a country is defined as federal and zero otherwise. Government size is measured by the logarithm of the share of general

[7]Some countries (e.g., the United States and Spain) have more than one level of government between the central level and the local level. In such cases, the *GFS Manual* (2001) groups the intermediate levels of government together with the level they are most closely associated with.

government final consumption expenditures in output, and trade openness is the sum of exports and imports of goods and services expressed as a share of output. We define five regions, namely East Asia & Pacific, Eastern Europe & Central Asia, Latin America & Caribbean, Africa, and OECD member countries.

3.3.2. Endogeneity Issues

When estimating equation (3.1) by ordinary least squares, there is a potential problem of reverse causality; that is, a higher rate of economic growth may cause a change in expenditure responsibilities of governments at the sub-national level. Another problem is that fiscal decentralization may capture the effect of omitted variables. To verify whether the reverse causality concern is valid, we need an instrumental variable approach. Surprisingly, the fiscal federalism literature has hardly addressed endogeneity issues. Exceptions are Fisman and Gatti (2002), who use the origin of a country's legal system, Enikolopov and Zhuravskaya (2007), who use the size of a country as an instrumental variable for fiscal decentralization, and Iimi (2005) and Martinez-Vazquez and McNab (2006), who use an internal instrument, namely the lag of the fiscal decentralization measure itself.

The external instruments of Fisman and Gatti (2002) and Enikolopov and Zhuravskaya (2007), who deal with the effect of fiscal federalism on corruption and political institutions rather than economic growth, are time invariant. Their instruments may perform well in a cross-country analysis but are less suitable in a panel data analysis where fiscal decentralization varies over time. Moreover, the instruments cannot be used at all when country fixed effects are taken into account.

Internal instruments, as used by Iimi (2005), do not suffer from this drawback but lead to a reduction in the number of observations; that is, one or more cross-sections of data are lost, reflecting the time lags. The reduction in the number of observations comes at a high cost in small samples. This disadvantage is especially large given that most fiscal decentralization studies use samples that are unbalanced.

We propose new instrumental variables that can tackle the above mentioned issues. Our approach in constructing instruments for fiscal decentralization is based on the assumption that legal system origin and size of a country may not only

be indicative for the degree of fiscal decentralization of a country but also for its development over time. We argue that countries similar in these aspects experience a similar process of fiscal decentralization.

The "similarity" between countries, however, does not have to be restricted to their size and legal origin, but may also be captured by other proxies such as their geographical distance or having the same federal system. Instrumental variables for fiscal decentralization of a country i are then a weighted average of the fiscal decentralization measure of "similar" countries. More specifically, we can define the instrumental variable for fiscal decentralization of country i at time t as follows

$$q_{it} = \sum_{j=1}^{N} \omega_{ij} f_{jt}, \qquad \omega_{ij} \equiv \begin{cases} d_{ij} / \sum_{j=1}^{N} d_{ij} & \text{for } i \neq j \\ 0 & \text{for } i = j \end{cases}, \tag{3.2}$$

where f_{jt} denotes the degree of fiscal decentralization of country j at time t, ω_{ij} denotes a weight, and d_{ij} measures the similarity of countries i and j. The weights are normalized so that they lie in the closed interval $[0, 1]$ and sum to unity.

Since the instrumental variables are based on a weighted average of countries in the sample, missing observations may lead to an inconsistency in the number of countries used in their construction. Therefore, we balance the sample by interpolating the fiscal decentralization variable for the missing values so that the same number of countries is used in every period.

We use several specifications to measure similarity. The first specification is based on having a common legal system origin, which is a dummy taking on a value of one if countries have the same legal system origin and zero otherwise. Based on La Porta et al. (1999), we define the following main categories of legal origin: British, French, German, Scandinavian, and Socialist. (Fisman and Gatti, 2002) find that "the proportion of public expenditures accounted for by state / local governments is much lower in French origin countries than in British origin countries" (p. 337), which, they argue, is in line with the affinity of a Civil legal code for government centralization.

The second is based on having the same federal system, which is based on the definition of whether a country is federal or not (e.g., Fan et al., 2009). Lijphart

(1984, p. 176) argues that "federalism and decentralization tend to go together".

As a third specification, we consider a measure based on geographical distance. More specifically, we use the inverse of the squared distance between the main cities of the countries i and j as a measure of similarity. This captures the idea that governments set their rate of fiscal decentralization close to that of their neighboring countries.

Finally, we use a measure of the relative size of countries i and j, which is given by

$$s_{ij} = \frac{s_i + s_j}{s_i + s_j + \xi|s_i - s_j|},$$

where s_i and s_j denote the size in squared kilometers of country i and country j, respectively, and $\xi \in [0, \infty)$ is the weight of the absolute size difference. It can be argued that the distance of the national government to its citizens increases with the size of a country making it less likely that policies of the national government are in line with the citizens' preferences and strengthening the case for more decentralization; see Panizza (1999, p. 104).

Table 3.2 gives an overview of the pairwise correlation coefficients of fiscal decentralization and the respective instrumental variables. The instruments based on countries having the same federal system display the strongest correlation with fiscal decentralization. This instrument is followed by instruments based on relative size of countries, where the correlation coefficient becomes larger when increasing the weight of the absolute size difference. Instruments based on legal origin and distance squared are less strongly correlated. Countries similar in federal system, size, legal origin, and geographical position thus seem to have a similar process of fiscal decentralization and therefore are likely to be valid instruments.[8]

When addressing the issue of reverse causality, we set μ_i to zero so that we do not control for country fixed effects. Since we estimate equation (3.1) with a pooled ordinary least squares estimator, this means we cannot completely correct for a possible omitted variable bias even when controlling for regional fixed effects. We

[8]The instrumental variables are valid if they are correlated with the fiscal decentralization measure but not with the error terms.

Table 3.2: Correlation Coefficients of Instrumental Variables

Variable	(2)	(3)	(4)	(5)				
				$\xi = 5$	$\xi = 10$	$\xi = 25$	$\xi = 50$	$\xi = 100$
(1) Fiscal decentralization	0.2785***	0.4482***	0.1741**	0.3480***	0.4305***	0.4987***	0.5255***	0.5350***
(2) Common legal system origin		0.1682**	-0.0007	-0.1698**	-0.1739**	-0.1753**	-0.1802**	-0.1882***
(3) Common federal system			0.0603	0.2465***	0.2721***	0.2789***	0.2743***	0.2651***
(4) Distance squared				0.3276***	0.3932***	0.4501***	0.4701***	0.4739***
(5) Relative country size								

Notes: Pairwise correlation coefficients of fiscal decentralization and potential instrumental variables. ***, **, and * denote significance at the 1, 5, and 10 percent level, respectively. Correlation coefficients are calculated using the sample of 56 countries over the period 1990–2007.

acknowledge that including country fixed effects solves the omitted variable bias, but this may come at a cost in the presence of measurement error. Hauk and Wacziarg (2009) shows that a fixed effects estimator exacerbates the bias arising from measurement error when the time persistence in the covariates is larger than that of the errors in measurement. Unfortunately, the trade-off between the omitted variable bias and measurement error bias cannot be resolved on theoretical grounds, but it has to be evaluated with the use of simulations. In the fiscal decentralization and economic growth nexus, even the latter approach may prove difficult given the lack of a theoretical framework that can provide guidance on choosing values for the parameters necessary for these simulations.

An alternative approach is to use a general method of moments estimator proposed by Arellano and Bond (1991). The advantage of this estimator is that it deals with the omitted variable bias, the measurement error bias, and biases arising from reverse causality. Disadvantages are the loss of time periods—which could bias estimates when the number of time periods is small, as in our case—and the problem of weak instruments. Even alternative instruments such as the general method of moments estimators proposed by Arellano and Bover (1995) and Blundell and Bond (1998), who address this last problem, are inadequate when the measurement error is correlated with the proposed instruments. This situation occurs when measurement errors are persistent over time. For growth regressions, Hauk and Wacziarg (2009) use simulations to determine to which extent these and other estimators address the different biases. Again, this approach may be applied to the fiscal decentralization and economic growth nexus once a theoretical framework is established. However, we leave this for future work.

3.3.3. Alternative Fiscal Decentralization Measures

Most studies measure the degree of fiscal decentralization by a country's sub-national government share in total government expenditures or revenues. Martinez-Vazquez and McNab (2003) criticize these measures for not accurately representing the degree to which these governments have policy autonomy. Thornton (2007) takes up this point and constructs a measure that takes the policy making authority of

Table 3.3: Correlation Coefficients of Fiscal Decentralization Measures

	Sample of 23 Countries			Sample of 15 Countries			
	(2)	(3)		(2)	(3)		
		I	II		I	II	III
(1) Expenditures	0.8028***	0.8222***	0.7425***	0.7814***	0.8207***	0.7439***	0.7673***
(2) Tax Revenues		0.9452***	0.7847***		0.9381***	0.7657***	0.6673***
(3) Tax Revenues Autonomy							

Notes: Pairwise correlation coefficients of several measures of fiscal decentralization. ***, **, * denote significance at the 1, 5, and 10 percent level, respectively. Correlations coefficients are calculated using samples of 23 and 15 countries countries over the period 1993–2007; see Table A.3. The reduction in the number of countries results from only including those countries for which sub-national governments have full discretion on rates, bases, and reliefs; see category *a* in Table A.4. Tax autonomy measures of 1995, 2001, and 2005 are used for the periods 1993–1997, 1998–2002, and 2003–2007, respectively. "I" takes all categories of tax autonomy into account; "II" takes all categories related to discretion on rates, bases, and reliefs into account; "III" takes only the category with full discretion on bases, and reliefs into account. See Table A.4 in the Appendix for an overview of all categories.

sub-national governments into account. More specifically, he takes the share of sub-national tax revenues in total tax revenues and multiplies this measure with an indicator of tax autonomy. This indicator of local government's tax autonomy is based on data provided by the OECD (1999), which distinguishes several categories of tax autonomy, ranging from full discretion on tax rates and reliefs (i.e., credits and allowances) to no discretion on rates and reliefs at all; see Table A.4 in the Appendix for an overview of all categories.

Whether a tax autonomy measure of fiscal decentralization affects the growth and fiscal decentralization nexus remains an open question. Such an analysis requires a counterfactual.[9] Using data of the the OECD (1999; 2006; 2009), we construct several autonomy-based measures of fiscal decentralization. More specifically, we employ the share of sub-national tax revenues in total tax revenues, where we only use those tax revenues on the sub-national level over which the corresponding governments have policy making authority. Since there is no clear definition of or consensus on the policy making authority of governments, we examine three different cases in which we give the tax autonomy categories of the OECD different weights; see Table A.4 in the Appendix.

Table 3.3 presents pairwise correlation coefficients of the different fiscal decentralization measures. The conventional measures of fiscal decentralization based on expenditures and tax revenues of the *Government and Finance Statistics* (2010) are highly correlated. Moreover, this correlation remains strong after we adjust the tax revenues measure with the tax autonomy data of the OECD. The conventional measures of fiscal decentralization thus seem a good approximation for measures that better reflect the true degree of fiscal autonomy of sub-national governments.

3.4. Estimation Results

This section discusses the estimation results and performs robustness checks. In the analyses, we deal with possible endogeneity problems and look at various measures

[9]Thornton (2007) only studies the effect of the constructed autonomy measure of fiscal decentralization and not the conventional measure itself.

of fiscal decentralization that differ in the degree in which they reflect the autonomy of sub-national governments.

3.4.1. Endogeneity Issues

Table 3.4 presents our main estimation results and focuses on the possible endogeneity issues concerning the relationship between fiscal decentralization and economic growth.

3.4.1.1. Instrumental Variables

The first column in panel (a) of Table 3.4 regresses the growth rate of real GDP per capita on fiscal decentralization, initial real GDP per capita, population growth, investment, and schooling. We estimate the equation by ordinary least squares (OLS), where standard errors are clustered at the country level since we could not reject the error terms to be serially uncorrelated. The estimation results are as follows. Initial real GDP per capita and population growth both enter with a negative and significant coefficient, and investment and schooling have positive and significant coefficients. These results are in line with most of the growth literature (Durlauf et al., 2005). The coefficient of fiscal decentralization is not significant.

Fiscal decentralization, however, enters with a positive and significant coefficient in the second column where we added federal system, government size, and trade openness. The coefficient on population growth is no longer significant. Federal system enters with a negative and significant coefficient. We find no evidence that the size of the government is associated with growth in real GDP per capita although being more open is positively associated with it.

We add regional dummies and time dummies in the third and fourth column, respectively, where OECD countries and the period 2005–2007 are the bases. The estimation results remain the same in sign and significance except for the coefficients on schooling and federal system, which are not significant anymore. Countries belonging to East Asia & Pacific, Eastern Europe, & Central Asia, and Africa grow at a lower rate than OECD countries. Compared to the period 2005–2007, growth in real GDP per capita is lower over the period 1990–1992 and 1999–2004. Based on

the estimation results of columns (2)–(4), a one standard deviation increase in fiscal decentralization is associated with an increase of the growth in real GDP per capita of a half percentage point.

We estimate the same four equations by two-stage least squares (2SLS) in columns (5)–(8), where we use the constructed variables based on common legal system origin and relative country size, with $\xi = 50$, as instruments for fiscal decentralization. For the instrumental variables to be valid, they should be both correlated with fiscal decentralization and uncorrelated with the model's error term.

To see if they satisfy the first criteria, we follow the criteria of Staiger and Stock (1997) and check whether the significance of the instruments in the first-stage regression is large enough; as a rule of thumb the corresponding F-statistic should be larger than 10. This is indeed the case. To test for the second criteria, we use the robust score test of overidentifying restrictions of Wooldridge (1995). We also use the regression-based test of Wooldridge (1995) to test for the endogeneity of fiscal decentralization. We use these tests rather than the standard tests since we cluster standard errors at the country level. The test statistics are never significant at conventional levels, so we cannot reject the null hypothesis of fiscal decentralization being exogenous, and the evidence suggests the fiscal instruments are valid.

The estimation results are similar in sign and significance for almost all variables. Point estimates are higher for fiscal decentralization. In the specification where we include both region and time dummies, however, the coefficient is no longer significant at conventional levels.[10]

For comparison, we perform the same analyses with instrumental variables that are commonly used in the literature on fiscal decentralization. These instruments are either internal, such as the lags of the fiscal decentralization measure itself, or external, such as country size and common legal system origin. Moreover, we look at our constructed variables based on common federal system and distance. Finally, the value of ξ is varied for the instruments used in columns (5)-(8) in Table 3.4 to see how this affects the estimation results.

[10]In column (4), the p-value corresponding to the coefficient of fiscal decentralization is 0.063, where in column (8) it is 0.129, so it is not significant at conventional levels.

Table 3.4: Fiscal Decentralization and Economic Growth
Panel (a): Preferred Instruments

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS				2SLS			
Fiscal decentralization	0.017	0.043**	0.043**	0.036*	0.022	0.054**	0.056**	0.037
	(0.016)	(0.020)	(0.019)	(0.019)	(0.019)	(0.026)	(0.024)	(0.024)
Initial real GDP per capita	-0.011***	-0.011***	-0.021***	-0.019***	-0.011***	-0.011***	-0.021***	-0.019***
	(0.003)	(0.003)	(0.005)	(0.005)	(0.003)	(0.003)	(0.005)	(0.005)
Population growth	-0.035**	-0.028	0.002	0.003	-0.034**	-0.027	0.004	0.003
	(0.015)	(0.017)	(0.016)	(0.015)	(0.015)	(0.017)	(0.016)	(0.014)
Investment	0.055***	0.047***	0.042***	0.035***	0.055***	0.047***	0.043***	0.035***
	(0.009)	(0.009)	(0.013)	(0.012)	(0.009)	(0.009)	(0.013)	(0.012)
Schooling	0.016*	0.015*	0.017*	0.012	0.016*	0.015*	0.017**	0.012
	(0.008)	(0.008)	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Federal system		-0.010*	-0.008	-0.007		-0.012**	-0.010**	-0.007
		(0.006)	(0.005)	(0.005)		(0.005)	(0.005)	(0.005)
Government size		-0.003	-0.006	-0.005		-0.004	-0.007	-0.005
		(0.010)	(0.010)	(0.010)		(0.009)	(0.009)	(0.009)
Trade openness		0.012***	0.015***	0.013**		0.013***	0.016***	0.013***
		(0.004)	(0.005)	(0.005)		(0.004)	(0.004)	(0.004)
East Asia & Pacific			-0.033**	-0.026*			-0.034**	-0.026**
			(0.014)	(0.014)			(0.014)	(0.013)
Eastern Europe & Central Asia			-0.009	-0.006			-0.008	-0.006
			(0.010)	(0.009)			(0.010)	(0.009)
Latin America & Caribbean			-0.024**	-0.025**			-0.023**	-0.025**
			(0.010)	(0.010)			(0.010)	(0.010)
Africa			-0.039***	-0.040***			-0.039***	-0.040***
			(0.012)	(0.013)			(0.012)	(0.012)
Period 1990-1992				-0.028**				-0.028**
				(0.014)				(0.013)
Period 1993-1995				-0.004				-0.004
				(0.004)				(0.004)
Period 1996-1998				-0.006				-0.006
				(0.009)				(0.008)
Period 1999-2001				-0.010**				-0.010***
				(0.004)				(0.004)
Period 2002-2004				-0.006**				-0.006**
				(0.003)				(0.002)
Constant	0.152**	0.135	0.321***	0.293***	0.153***	0.134*	0.321***	0.293***
	(0.059)	(0.081)	(0.102)	(0.090)	(0.058)	(0.079)	(0.100)	(0.086)
Observations	201	201	201	201	201	201	201	201
Countries	56	56	56	56	56	56	56	56
Adj. R^2	0.316	0.345	0.375	0.415	0.316	0.344	0.373	0.415
First-stage F					25.253	12.782	14.040	10.307
p-value					0.000	0.000	0.000	0.000
Regression-based F					0.103	0.232	0.306	0.003
p-value					0.749	0.632	0.582	0.954
Robust Score					2.233	2.740	1.053	0.632
p-value					0.135	0.098	0.305	0.427

(*Continued*)

Notes: Standard errors are clustered at the country level. ***, **, and * denote significance at the 1, 5, and 10 percent level, respectively. F statistics for the serial correlation test, as described by Drukker (2003), for columns (1)–(4) are 11.02, 8.794, 8.794, and 8.235, respectively, which means we reject the null-hypothesis of no serial correlation in all cases. The variables based on common legal system origin and relative country size, with $\xi = 50$, are used as instruments for fiscal decentralization in columns (5)–(8).

Using the lags of fiscal decentralization as an instrumental variable leads to a loss of observations, which can be quite large when the data sample is unbalanced, as is the case in our sample. Panel (b) of Table 3.4 repeats the analyses of panel (a) with the reduced sample, where the number of observations has been reduced from 201 to 126 and the number of countries from 56 to 37 (Table A.3). Although the estimations results are similar for most variables, fiscal decentralization is no longer significant when estimating the equations with ordinary least squares. However, it is very likely it is not the reduction in observations but rather the selection of countries that leads to this result since similar results are found when repeating the analyses of columns (1)–(4) using the 37 countries of the reduced sample.

Columns (13)–(16) of panel (b) give the estimation results where we estimate the equations by two-stage least squares using the lag of fiscal decentralization as its instrument. Fiscal decentralization now enters with a significant coefficient, though only at the 10 percent level. As with the external instrumental variables, point estimates of the fiscal decentralization coefficients are higher, and we cannot reject the null of fiscal decentralization being exogenous. However, we are unable to test whether the instruments are uncorrelated with the error term since we only have one instrumental variable. Having only one instrumental variable is a further disadvantage of using the lag of fiscal decentralization as an instrumental variable.

Estimation results corresponding to conventional external instrumental variables used in the literature are given in the first four columns of panel (c). The last four columns of this panel present the estimations results corresponding to our constructed variables based on common federal system and distance. None of these instrumental variables can be considered as valid according to the criteria of Staiger and Stock (1997). A notable exception is presented in column (24), where the joint significance of the instrumental variables is large enough to be considered as valid instruments. Moreover, in this case the instruments seems to outperform those based on common legal system origin and relative country size.

To see how the value of ξ affects the results, we look at the distribution of relative country size for different values; see Figure 3.1. The value of ξ captures the degree of similarity of countries that differ in their size. A small value of ξ means absolute size

Table 3.4: Fiscal Decentralization and Economic Growth
Panel (b): Alternative Instruments

	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	OLS				2SLS			
Fiscal decentralization	-0.005	0.040*	0.038	0.037	0.001	0.044*	0.043*	0.041*
	(0.018)	(0.024)	(0.023)	(0.024)	(0.019)	(0.023)	(0.022)	(0.023)
Initial real GDP per capita	-0.010***	-0.010***	-0.016***	-0.017***	-0.010***	-0.010***	-0.017***	-0.017***
	(0.003)	(0.003)	(0.006)	(0.006)	(0.003)	(0.003)	(0.005)	(0.005)
Population growth	-0.043***	-0.034**	-0.022	-0.025	-0.043***	-0.034***	-0.022	-0.024
	(0.015)	(0.013)	(0.021)	(0.022)	(0.014)	(0.013)	(0.020)	(0.020)
Investment	0.048***	0.042***	0.037***	0.034***	0.049***	0.042***	0.037***	0.035***
	(0.010)	(0.008)	(0.011)	(0.011)	(0.010)	(0.008)	(0.011)	(0.011)
Schooling	0.009	0.009	0.016*	0.017**	0.009	0.009	0.016**	0.017**
	(0.009)	(0.008)	(0.008)	(0.008)	(0.009)	(0.008)	(0.008)	(0.008)
Federal system		-0.016***	-0.013**	-0.013**		-0.016***	-0.014***	-0.013***
		(0.005)	(0.005)	(0.006)		(0.005)	(0.005)	(0.005)
Government size		-0.002	-0.008	-0.007		-0.002	-0.008	-0.007
		(0.009)	(0.011)	(0.010)		(0.009)	(0.010)	(0.009)
Trade openness		0.014***	0.016***	0.017***		0.015***	0.016***	0.017***
		(0.004)	(0.005)	(0.005)		(0.004)	(0.004)	(0.005)
East Asia & Pacific			-0.022**	-0.021*			-0.021**	-0.021**
			(0.009)	(0.011)			(0.009)	(0.010)
Eastern Europe & Central Asia			-0.007	-0.007			-0.007	-0.007
			(0.010)	(0.011)			(0.010)	(0.010)
Latin America & Caribbean			-0.020*	-0.020*			-0.020**	-0.020**
			(0.010)	(0.010)			(0.009)	(0.009)
Africa			-0.013	-0.013			-0.014	-0.014
			(0.010)	(0.010)			(0.009)	(0.009)
Period 1990-1992								
Period 1993-1995				-0.002				-0.002
				(0.004)				(0.004)
Period 1996-1998				0.001				0.001
				(0.010)				(0.009)
Period 1999-2001				-0.005				-0.005
				(0.004)				(0.004)
Period 2002-2004				-0.005**				-0.005**
				(0.002)				(0.002)
Constant	0.097	0.093	0.189**	0.191**	0.098*	0.092	0.190***	0.191***
	(0.058)	(0.066)	(0.072)	(0.078)	(0.055)	(0.063)	(0.068)	(0.072)
Observations	126	126	126	126	126	126	126	126
Countries	37	37	37	37	37	37	37	37
Adj. R^2	0.299	0.441	0.448	0.442	0.298	0.441	0.447	0.442
First-stage F					1034.786	587.063	416.806	387.178
p-value					0.000	0.000	0.000	0.000
Regression-based F					2.783	0.877	0.975	0.653
p-value					0.104	0.355	0.330	0.424

(*Continued*)

Notes: Standard errors are clustered at the country level. ***, **, and * denote significance at the 1, 5, and 10 percent level, respectively.

Table 3.4: Fiscal Decentralization and Economic Growth
Panel (c): Alternative Instruments

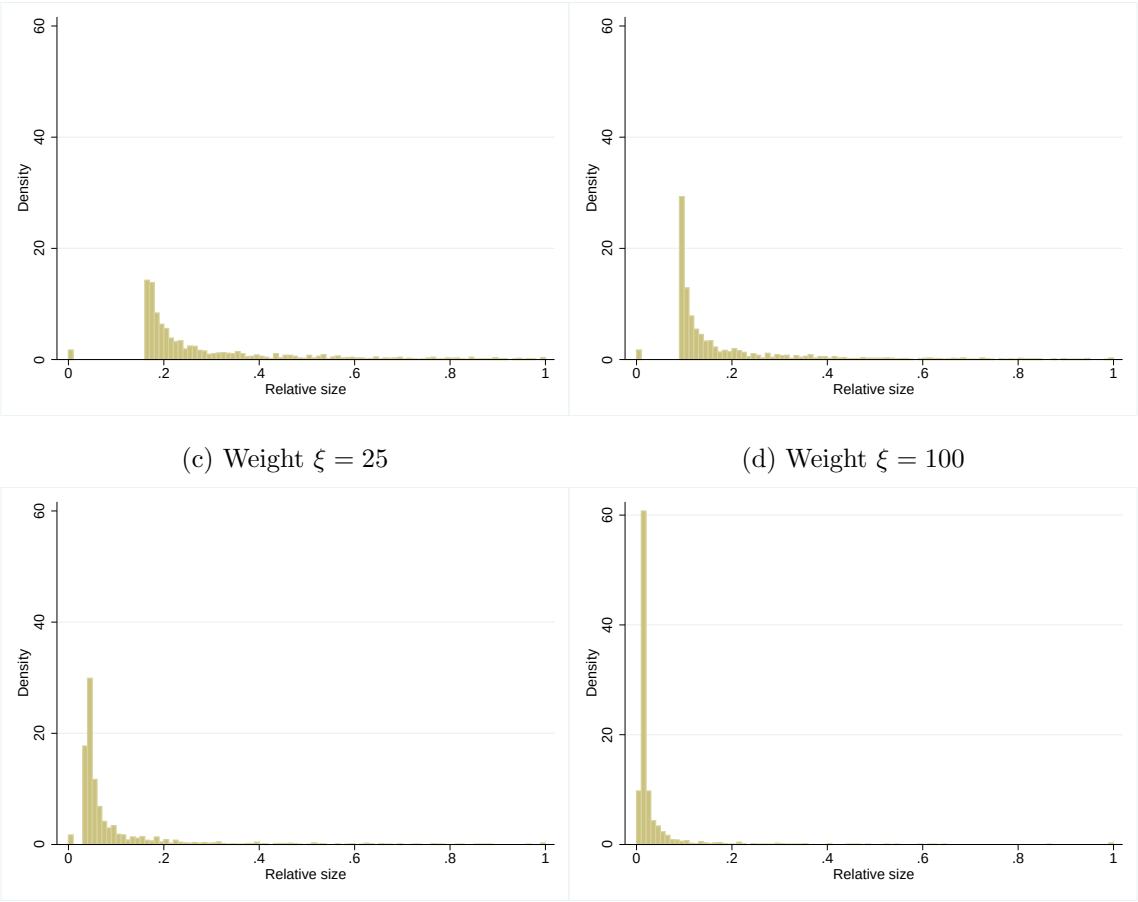
	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
Fiscal decentralization	0.032	0.094**	0.065***	0.054**	-0.013	-0.008	-0.040	0.053**
	(0.023)	(0.038)	(0.025)	(0.023)	(0.031)	(0.095)	(0.101)	(0.021)
Initial real GDP per capita	-0.011***	-0.011***	-0.021***	-0.020***	-0.010***	-0.011***	-0.021***	-0.020***
	(0.003)	(0.003)	(0.005)	(0.005)	(0.003)	(0.003)	(0.005)	(0.005)
Population growth	-0.034**	-0.023	0.005	0.005	-0.036**	-0.034**	-0.009	0.005
	(0.015)	(0.017)	(0.016)	(0.015)	(0.015)	(0.014)	(0.018)	(0.015)
Investment	0.055***	0.048***	0.043***	0.037***	0.053***	0.045***	0.035**	0.037***
	(0.009)	(0.010)	(0.012)	(0.011)	(0.010)	(0.009)	(0.015)	(0.012)
Schooling	0.016*	0.013	0.016*	0.012	0.017*	0.017*	0.020*	0.012
	(0.008)	(0.009)	(0.009)	(0.008)	(0.009)	(0.010)	(0.011)	(0.008)
Federal system		-0.018***	-0.011**	-0.009**		-0.002	0.005	-0.009
		(0.006)	(0.005)	(0.004)		(0.016)	(0.017)	(0.006)
Government size		-0.007	-0.007	-0.007		0.001	-0.000	-0.007
		(0.011)	(0.010)	(0.010)		(0.015)	(0.015)	(0.010)
Trade openness		0.015***	0.017***	0.014***		0.009	0.010	0.014***
		(0.004)	(0.004)	(0.004)		(0.007)	(0.008)	(0.004)
East Asia & Pacific			-0.034**	-0.028**			-0.027	-0.028**
			(0.014)	(0.013)			(0.019)	(0.014)
Eastern Europe & Central Asia			-0.010	-0.006			-0.008	-0.006
			(0.011)	(0.009)			(0.010)	(0.009)
Latin America & Caribbean			-0.023**	-0.024**			-0.026***	-0.024**
			(0.010)	(0.010)			(0.010)	(0.010)
Africa			-0.039***	-0.040***			-0.040**	-0.040***
			(0.012)	(0.012)			(0.016)	(0.012)
Period 1990-1992				-0.027**				-0.027**
				(0.013)				(0.013)
Period 1993-1995				-0.003				-0.003
				(0.004)				(0.004)
Period 1996-1998				-0.005				-0.005
				(0.008)				(0.008)
Period 1999-2001				-0.010**				-0.010***
				(0.004)				(0.004)
Period 2002-2004				-0.005**				-0.005**
				(0.002)				(0.002)
Constant	0.155***	0.130	0.321***	0.295***	0.147**	0.140*	0.321***	0.295***
	(0.059)	(0.088)	(0.102)	(0.089)	(0.059)	(0.081)	(0.097)	(0.089)
Observations	201	201	201	201	201	201	201	201
Countries	56	56	56	56	56	56	56	56
Adj. R^2	0.312	0.313	0.369	0.411	0.300	0.312	0.289	0.412
First-stage F	8.178	3.572	6.363	6.082	8.294	4.595	4.214	17.116
p-value	0.000	0.005	0.000	0.000	0.001	0.014	0.020	0.000
Regression-based F	0.718	4.111	0.860	0.617	1.268	0.287	0.650	1.375
p-value	0.400	0.047	0.358	0.435	0.265	0.594	0.424	0.246
Robust Score	10.501	5.958	7.545	6.937	1.867	1.488	0.733	0.167
p-value	0.062	0.310	0.183	0.225	0.172	0.222	0.392	0.683

Notes: Standard errors are clustered at the country level. ***, **, and * denote significance at the 1, 5, and 10 percent level, respectively. All equations are estimated by two-stage least squares.

differences are given a low weight, which means even countries considerably different in size are considered as relatively similar. Absolute size differences are given a high weight when the value of ξ is large so that countries of almost the same size are considered as relatively dissimilar.[11]

Figure 3.1: Distribution of Relative Size with Different Weights

(a) Weight $\xi = 5$ (b) Weight $\xi = 10$



(c) Weight $\xi = 25$ (d) Weight $\xi = 100$

Notes: All figures are based on the sample of 56 countries.

From Figure 3.1 it can be seen that increasing the weight of absolute size differences leads to a lower average relative country size. At the same time, the percentage of relative country size with a value close to zero increases. As ξ becomes larger, only countries very similar in size get a substantial weight in constructing the instrumental variables for fiscal decentralization, resulting in an increase in the correlation coefficient between the constructed variable and fiscal decentralization; see Table

[11]For example, when $\xi = 0$, the relative size of two countries always equals one irrespective of their actual size. When $\lim_{\xi \to \infty}$, the relative size of a country goes to zero even if the difference in size is only a squared kilometer.

3.2. The consequences of varying the value of ξ for the estimation results are given in Table 3.5.

Table 3.5: Alternative Weights of the Absolute Size Difference

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	$\xi = 5$				$\xi = 10$			
Fiscal decentralization	0.052*	0.110**	0.110**	0.068**	0.037	0.085***	0.086***	0.054*
	(0.031)	(0.043)	(0.044)	(0.032)	(0.024)	(0.032)	(0.033)	(0.028)
Initial real GDP per capita	-0.012***	-0.011***	-0.021***	-0.020***	-0.011***	-0.011***	-0.021***	-0.020***
	(0.003)	(0.003)	(0.005)	(0.005)	(0.003)	(0.003)	(0.005)	(0.005)
Population growth	-0.033**	-0.021	0.011	0.007	-0.034**	-0.023	0.008	0.005
	(0.016)	(0.020)	(0.020)	(0.016)	(0.015)	(0.019)	(0.018)	(0.015)
Investment	0.056***	0.049***	0.046***	0.039***	0.055***	0.048***	0.045***	0.037***
	(0.010)	(0.011)	(0.014)	(0.012)	(0.010)	(0.010)	(0.013)	(0.012)
Schooling	0.015*	0.012	0.015	0.011	0.015*	0.013	0.016*	0.012
	(0.008)	(0.009)	(0.010)	(0.008)	(0.008)	(0.008)	(0.009)	(0.008)
Federal system		-0.021***	-0.018***	-0.011**		-0.017***	-0.014***	-0.009*
		(0.006)	(0.007)	(0.005)		(0.005)	(0.005)	(0.005)
Government size		-0.008	-0.010	-0.008		-0.006	-0.009	-0.007
		(0.009)	(0.009)	(0.009)		(0.009)	(0.009)	(0.009)
Trade openness		0.016***	0.019***	0.015***		0.014***	0.018***	0.014***
		(0.004)	(0.005)	(0.005)		(0.004)	(0.004)	(0.005)
East Asia & Pacific			-0.037**	-0.029**			-0.036**	-0.028**
			(0.018)	(0.014)			(0.016)	(0.013)
Eastern Europe & Central Asia			-0.008	-0.006			-0.008	-0.006
			(0.010)	(0.009)			(0.010)	(0.009)
Latin America & Caribbean			-0.022**	-0.023**			-0.022**	-0.024**
			(0.011)	(0.010)			(0.010)	(0.010)
Africa			-0.038***	-0.040***			-0.038***	-0.040***
			(0.012)	(0.012)			(0.011)	(0.012)
Period 1990-1992				-0.026*				-0.027**
				(0.014)				(0.013)
Period 1993-1995				-0.002				-0.003
				(0.004)				(0.004)
Period 1996-1998				-0.005				-0.005
				(0.008)				(0.008)
Period 1999-2001				-0.009**				-0.010**
				(0.004)				(0.004)
Period 2002-2004				-0.005**				-0.005**
				(0.002)				(0.002)
Constant	0.158**	0.128	0.322***	0.297***	0.155***	0.130	0.322***	0.295***
	(0.063)	(0.089)	(0.114)	(0.093)	(0.060)	(0.084)	(0.107)	(0.089)
Observations	201	201	201	201	201	201	201	201
Countries	56	56	56	56	56	56	56	56
Adj. R^2	0.295	0.290	0.320	0.403	0.309	0.323	0.353	0.411
First-stage F	16.459	9.248	10.702	6.231	22.620	10.775	12.379	7.485
p-value	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.001
Regression-based F	1.732	2.632	2.435	1.134	1.055	1.941	1.811	0.495
p-value	0.194	0.110	0.124	0.292	0.309	0.169	0.184	0.485
Robust Score	0.379	0.389	0.001	0.134	1.117	1.199	0.214	0.316
p-value	0.538	0.533	0.975	0.714	0.291	0.273	0.644	0.574

(*Continued*)

Table 3.5: Alternative Weights of the Absolute Size Difference (Continued)

	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	$\xi = 25$				$\xi = 100$			
Fiscal decentralization	0.026	0.064**	0.065**	0.043*	0.018	0.046*	0.050**	0.033
	(0.020)	(0.026)	(0.026)	(0.025)	(0.019)	(0.027)	(0.024)	(0.024)
Initial real GDP per capita	-0.011***	-0.011***	-0.021***	-0.019***	-0.011***	-0.011***	-0.021***	-0.019***
	(0.003)	(0.003)	(0.005)	(0.005)	(0.003)	(0.003)	(0.005)	(0.005)
Population growth	-0.034**	-0.026	0.005	0.004	-0.034**	-0.028	0.003	0.003
	(0.015)	(0.018)	(0.016)	(0.015)	(0.015)	(0.017)	(0.016)	(0.014)
Investment	0.055***	0.047***	0.043***	0.036***	0.055***	0.047***	0.042***	0.035***
	(0.009)	(0.009)	(0.013)	(0.012)	(0.009)	(0.009)	(0.013)	(0.012)
Schooling	0.016*	0.014*	0.016*	0.012	0.016*	0.015*	0.017**	0.012
	(0.008)	(0.008)	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Federal system		-0.014***	-0.011**	-0.008		-0.011**	-0.009*	-0.006
		(0.004)	(0.005)	(0.005)		(0.005)	(0.005)	(0.005)
Government size		-0.004	-0.007	-0.006		-0.003	-0.006	-0.005
		(0.009)	(0.009)	(0.009)		(0.009)	(0.009)	(0.009)
Trade openness		0.013***	0.017***	0.014***		0.012***	0.016***	0.013***
		(0.004)	(0.004)	(0.004)		(0.004)	(0.004)	(0.004)
East Asia & Pacific			-0.034**	-0.027**			-0.033**	-0.026**
			(0.014)	(0.013)			(0.014)	(0.013)
Eastern Europe & Central Asia			-0.008	-0.006			-0.009	-0.006
			(0.010)	(0.009)			(0.010)	(0.009)
Latin America & Caribbean			-0.023**	-0.024**			-0.024**	-0.025**
			(0.010)	(0.010)			(0.010)	(0.010)
Africa			-0.039***	-0.040***			-0.039***	-0.040***
			(0.012)	(0.012)			(0.012)	(0.012)
Period 1990-1992				-0.028**				-0.028**
				(0.013)				(0.013)
Period 1993-1995				-0.004				-0.005
				(0.004)				(0.004)
Period 1996-1998				-0.006				-0.006
				(0.008)				(0.008)
Period 1999-2001				-0.010**				-0.010***
				(0.004)				(0.004)
Period 2002-2004				-0.006**				-0.006**
				(0.002)				(0.002)
Constant	0.154***	0.133	0.321***	0.294***	0.152***	0.134*	0.321***	0.292***
	(0.059)	(0.081)	(0.102)	(0.087)	(0.058)	(0.079)	(0.099)	(0.085)
Observations	201	201	201	201	201	201	201	201
Countries	56	56	56	56	56	56	56	56
Adj. R^2	0.314	0.339	0.369	0.415	0.316	0.345	0.375	0.415
First-stage F	24.817	11.902	13.198	8.961	24.656	13.563	15.092	11.750
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Regression-based F	0.372	0.801	0.820	0.084	0.009	0.022	0.072	0.014
p-value	0.545	0.375	0.369	0.773	0.923	0.883	0.789	0.906
Robust Score	1.888	2.219	0.729	0.519	2.452	3.094	1.295	0.726
p-value	0.169	0.136	0.393	0.471	0.117	0.079	0.255	0.394

Notes: Standard errors are clustered at the country level. ***, **, and * denote significance at the 1, 5, and 10 percent level, respectively. All equations are estimated by two-stage least squares.

Table 3.5 repeats the two-stage least squares estimations of columns (5)–(8) of Table 3.4. When absolute size differences are given a small weight, the constructed instrumental variables are poor or even invalid instruments based on their joint significance in the first stage regression. Moreover, point estimates of the fiscal

decentralization coefficient are almost twice as large compared to the estimation results by ordinary least squares. Increasing the value of ξ improves the strength of the instruments and leads to lower point estimates of the fiscal decentralization coefficients. For the cases where the instruments are valid, we cannot reject the null of fiscal decentralization being exogenous, and the evidence suggest the instruments are uncorrelated with the error term.

3.4.1.2. Fixed Effects and a Non-linear Relationship

A way to deal with the omitted variable bias is including country specific fixed effects in the regression specification. When regressing the growth rate of GDP per capita on fiscal decentralization, population growth, investment, schooling, government size, trade openness, and country dummies, fiscal decentralization never enters with a significant coefficient.

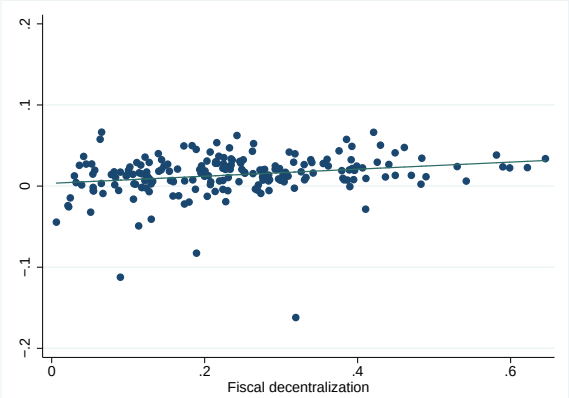
A possible explanation for why we do not find a relationship between fiscal decentralization and economic growth is given in Figure 3.2, which presents augmented partial residual plots under different specifications. Figure 3.2 shows that the relationship between fiscal decentralization and economic growth may no longer be linear once country dummies are included in the analysis. This finding is confirmed in Table 3.6. In the first column, we regress the growth rate of real GDP per capita on fiscal decentralization, fiscal decentralization squared, population growth, investment, schooling, government size, and trade openness. The evidence suggest there is no relationship between fiscal decentralization and economic growth. However, when adding country dummies in the second column, we find that the relationship is non-linear. More specifically, the marginal effect is zero at a fiscal decentralization ratio of 23 percent. At the 25th and 75th percentile, a one standard deviation increase in fiscal decentralization is associated with a change in the growth rate of real GDP per capita of 0.63 and -0.53 percentage points, respectively.[12]

In column (3), we estimate the equation of column (2) by two-stage least squares, where we use our the constructed variables based on common legal system origin and relative country size as instruments for fiscal decentralization. The evidence suggests

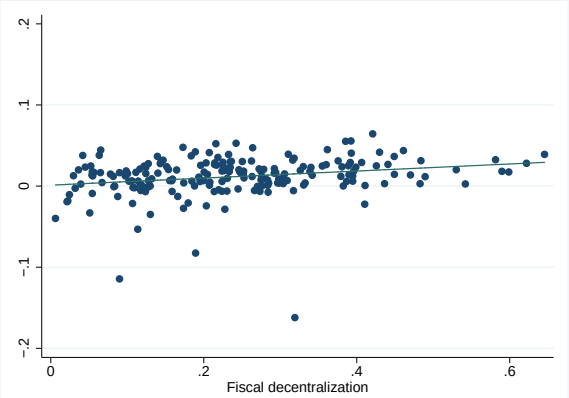
[12]Fiscal decentralization ratios at the 25th and 75th percentile are around 13 and 36 percent, respectively.

Figure 3.2: Augmented Partial Residual Plots

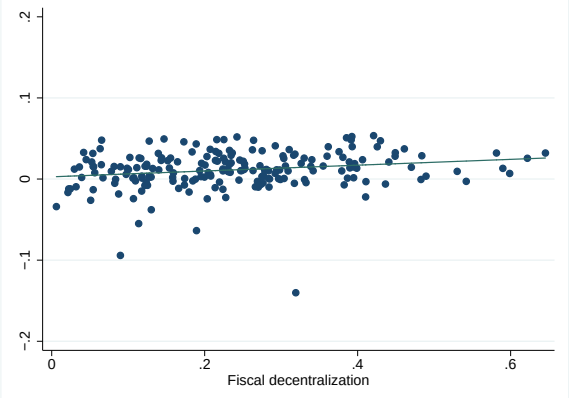
(a) No Dummies



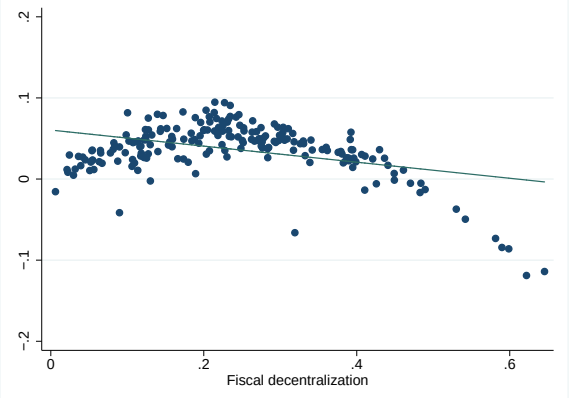
(b) Region Dummies



(c) Region and time Dummies



(d) Country Dummies



Notes: All figures are based on the sample of 56 countries over the period 1990–2007.

Table 3.6: Fixed Effects and a Non-linear Relationship

	(1) OLS	(2) OLS	(3) 2SLS	(4) OLS	(5) OLS	(6) 2SLS
Fiscal decentralization	0.046	0.484*	0.654	0.100	0.435**	0.452
	(0.072)	(0.243)	(0.579)	(0.073)	(0.162)	(0.282)
Fiscal decentralization squared	-0.060	-1.053**	-1.592	-0.180	-0.727**	-0.588
	(0.112)	(0.504)	(1.590)	(0.113)	(0.319)	(0.373)
Population growth	-0.039**	-0.060	-0.054	-0.034**	-0.093***	-0.095***
	(0.020)	(0.043)	(0.053)	(0.016)	(0.034)	(0.029)
Investment	0.060***	0.063***	0.065***	0.038***	0.041***	0.035**
	(0.013)	(0.024)	(0.017)	(0.013)	(0.014)	(0.017)
Schooling	0.005	-0.033	-0.030	0.001	-0.005	-0.008
	(0.013)	(0.021)	(0.028)	(0.014)	(0.021)	(0.020)
Government size	-0.015	0.006	0.004	-0.012	-0.005	-0.006
	(0.010)	(0.051)	(0.041)	(0.008)	(0.030)	(0.025)
Trade openness	0.008	0.066**	0.068***	0.010**	0.033***	0.029***
	(0.005)	(0.030)	(0.021)	(0.004)	(0.007)	(0.006)
Constant	-0.016	-0.161	-0.120	-0.047	-0.273***	-0.328***
	(0.081)	(0.207)	(0.186)	(0.060)	(0.094)	(0.123)
Country Dummies	No	Yes	Yes	No	Yes	Yes
Observations	201	201	201	126	126	126
Countries	56	56	56	37	37	37
Adj. R^2	0.246	0.542	0.524	0.278	0.607	0.596
First-stage F			2.600			2.242
p-value			0.046			0.121
Regression-based F			0.047			0.360
p-value			0.954			0.700
Robust Score			7.284			
p-value			0.026			

Notes: Standard errors are clustered at the country level. ***, **, and * denote significance at the 1, 5, and 10 percent level, respectively.

our instruments or no longer valid once we control for fixed effects in the analysis. To see whether internal instruments perform better under these circumstances, we repeat the analyses using the reduced sample and use the lag of fiscal decentralization as an instrumental variable. The estimation results are given in columns (4)–(6). We still find evidence for a non-linear relationship when fixed effects are included. At the same time, including fixed effects in the analysis causes the internal instruments to be no longer valid. This means that neither conventional, nor our instrumental variables can be used when country fixed effects are controlled for.

3.4.2. Alternative Fiscal Decentralization Measures

Table 3.7 studies whether the relationship between fiscal decentralization and economic growth changes when alternative measures of fiscal decentralization are used. We regress the growth rate of real GDP per capita on initial real GDP per capita, population growth, investment, schooling, federal system, government size, trade openness, and a measure of fiscal decentralization. In the first column, this measure is defined as the share of sub-national tax revenues in general tax revenues. Tax revenues at the sub-national level are adjusted for the degree of tax autonomy in columns (2) and (3). We take all tax autonomy categories of the OECD into account in the second column, where lower weights are given to categories with low degrees of autonomy.[13] In the third column, we restrict sub-national taxes revenues to those taxes for which sub-national governments have full discretion on both rates and reliefs and those for which they have full discretion on rates only. Our standard measure of fiscal decentralization based on expenditure data is used in the fourth column as a counterfactual.

None of the estimation results suggest there is a relationship between fiscal decentralization and economic growth. A possible explanation may be the small number of observations as a result of using alternative fiscal decentralization measures. Therefore, we repeat the analyses in columns (5)–(8) but use yearly data rather than three year averages. The findings, however, remain the same.

Alternative measures of fiscal decentralization do matter when we only consider

[13]See Table A.4 for an overview of the different categories and corresponding weights.

Table 3.7: Fiscal Decentralization Autonomy Measures

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		3-year average				yearly		
Case		I	II			I	II	
Tax revenues	0.006				0.003			
	(0.012)				(0.013)			
Tax revenues: Autonomy		0.009	0.010			0.009	0.011	
		(0.013)	(0.011)			(0.014)	(0.014)	
Expenditures				0.017				0.015
				(0.018)				(0.020)
Initial real GDP per capita	-0.004	-0.005	-0.005	-0.005	-0.003	-0.003	-0.004	-0.004
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Population growth	-0.025	-0.026	-0.029	-0.024	-0.038**	-0.038**	-0.041**	-0.037**
	(0.018)	(0.018)	(0.018)	(0.018)	(0.016)	(0.016)	(0.017)	(0.015)
Investment	0.024*	0.025*	0.026**	0.025**	0.033**	0.034**	0.035***	0.034***
	(0.013)	(0.012)	(0.012)	(0.011)	(0.012)	(0.012)	(0.012)	(0.012)
Schooling	0.019*	0.020*	0.020*	0.018*	0.016	0.017	0.017	0.016
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.011)	(0.011)	(0.010)
Federal system	-0.009***	-0.010***	-0.009***	-0.011***	-0.009***	-0.009***	-0.009***	-0.011***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Government size	-0.002	-0.001	-0.001	-0.002	-0.005	-0.005	-0.005	-0.006
	(0.006)	(0.006)	(0.007)	(0.007)	(0.007)	(0.008)	(0.008)	(0.008)
Trade openness	0.006**	0.006**	0.006**	0.006*	0.006*	0.006*	0.006*	0.006*
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Constant	0.072	0.073	0.070	0.080	0.021	0.026	0.026	0.030
	(0.090)	(0.089)	(0.089)	(0.089)	(0.074)	(0.075)	(0.077)	(0.075)
Observations	90	90	90	90	236	236	236	236
Countries	23	23	23	23	23	23	23	23
Adj. R^2	0.239	0.242	0.247	0.251	0.155	0.158	0.161	0.161

(*Continued*)

Table 3.7: Fiscal Decentralization Autonomy Measures (Continued)

	(9)	(10)	(11)	(12)	(13)
Case		I	II	III	
Tax revenues	0.015				
	(0.014)				
Tax revenues: Autonomy		0.020	0.021*	0.032**	
		(0.013)	(0.011)	(0.013)	
Expenditures					0.051**
					(0.018)
Constant	0.150*	0.154*	0.154*	0.120	0.175**
	(0.082)	(0.082)	(0.079)	(0.071)	(0.074)
Initial real GDP per capita	0.000	-0.001	-0.001	-0.000	-0.005
	(0.004)	(0.005)	(0.005)	(0.005)	(0.003)
Population growth	0.004	-0.000	-0.005	-0.011	-0.003
	(0.020)	(0.019)	(0.018)	(0.017)	(0.018)
Investment	0.037***	0.039***	0.041***	0.037***	0.036***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Schooling	0.024**	0.026***	0.028***	0.027***	0.029**
	(0.009)	(0.008)	(0.008)	(0.008)	(0.010)
Federal system	-0.007*	-0.007**	-0.006*	-0.007*	-0.014**
	(0.003)	(0.003)	(0.003)	(0.003)	(0.005)
Government size	0.009	0.009	0.010	0.010	0.006
	(0.007)	(0.007)	(0.008)	(0.007)	(0.007)
Trade openness	0.009***	0.010***	0.010***	0.009***	0.012***
	(0.003)	(0.003)	(0.002)	(0.002)	(0.003)
Fiscal decentralization measures					
Tax revenues	0.015				
	(0.014)				
Tax revenues: Autonomy		0.020	0.021*	0.032**	
		(0.013)	(0.011)	(0.013)	
Expenditures					0.051**
					(0.018)
Constant	0.150*	0.154*	0.154*	0.120	0.175**
	(0.082)	(0.082)	(0.079)	(0.071)	(0.074)
Observations	50	50	50	50	50
Countries	15	15	15	15	15
Adj. R^2	0.309	0.327	0.346	0.357	0.389

Notes: Standard errors are clustered at the country level. ***, **, and * denote significance at the 1, 5, and 10 percent level, respectively. All equations are estimated by ordinary least squares.

those tax revenues for which sub-national governments have full discretion on both rates and reliefs; case III in Table A.4 in the Appendix. This restriction, however, leads to a reduction in the number of countries to 15. For the reduced sample, we find that the fiscal decentralization measure based on tax revenue data does not enter with a significant coefficient; see column (9). Once we control for the autonomy of sub-national governments in columns (10)–(12), the coefficient of fiscal decentralization does enter with a significant coefficient. The same holds for our conventional measure of fiscal decentralization based on expenditure data. This implies that it is not so much the use of alternative measures of fiscal decentralization that may change its relationship with economic growth but rather the accompanied change in the sample of countries.

3.4.3. Robustness Analyses

Table 3.8 presents estimation results of a wide variety of robustness analyses. In all cases, we regress the growth rate of real GDP per capita on initial real GDP per capita, population growth, investment, schooling, federal system, government size, trade openness, and fiscal decentralization. These estimation results can be compared to column (2) of Table 3.4. To conserve on space, we only present the coefficient of fiscal decentralization, where we use our standard measure of fiscal decentralization unless indicated otherwise. We vary the fiscal decentralization measures, the frequency—i.e., yearly, 3-year average, 6-year average, 9-year average, and 18-year average—of the data used, the time period, and finally we control for outliers. In some of these cases, we look at the effects for OECD member countries and other countries, separately.

Point estimates are lower, but still significant, when using alternative fiscal decentralization measures based on revenue and expenditure data of the *Government Finance Statistics* (2010). Based on the alternative measures, a one standard deviation increase in fiscal decentralization implies an increase in economic growth of around a third of a percentage point. Estimation results are similar though when varying the frequency of the data used, implying that the relationship between fiscal decentralization and economic growth holds for both the short and long run. An

Table 3.8: Fiscal Decentralization and Economic Growth: Robustness Analyses

Measure	Data	Period	Coefficient	Observations	Number of Countries	Type of Countries
Revenues	3-year average	1990–2007	0.036**	179	56	All
			(0.016)			
Revenues, taxes	3-year average	1990–2007	0.025*	179	56	All
			(0.014)			
Expenditures, all	3-year average	1990–2007	0.044***	179	56	All
			(0.016)			
Expenditures, subset I[a]	3-year average	1990–2007	0.021*	179	56	All
			(0.011)			
Expenditures, subset II[b]	3-year average	1990–2007	0.026**	179	56	All
			(0.012)			
Expenditures, all	yearly	1990–2007	0.057**	414	38	All
			(0.027)			
Expenditures, all	yearly	1990–2007	0.035**	261	21	OECD
			(0.013)			
Expenditures, all	yearly	1990–2007	0.127**	153	17	non OECD
			(0.044)			
Expenditures, all	3-year average	1990–2007	0.051*	165	38	All
			(0.028)			
Expenditures, all	3-year average	1990–2007	0.043***	99	21	OECD
			(0.012)			
Expenditures, all	3-year average	1990–2007	0.103	66	17	non OECD
			(0.070)			
Expenditures, all	6-year average	1990–2007	0.045**	100	38	All
			(0.022)			
Expenditures, all	6-year average	1990–2007	0.039**	58	21	OECD
			(0.014)			
Expenditures, all	6-year average	1990–2007	0.088	42	17	non OECD
			(0.057)			
Expenditures, all	9-year average	1990–2007	0.052**	65	38	All
			(0.023)			
Expenditures, all	9-year average	1990–2007	0.030**	39	21	OECD
			(0.011)			
Expenditures, all	9-year average	1990–2007	0.117*	26	17	non OECD
			(0.058)			
Expenditures, all	18-year average	1990–2007	0.012	38	38	All
			(0.014)			
Expenditures, all	18-year average	1990–2007	0.031*	21	21	OECD
			(0.018)			
Expenditures, all	18-year average	1990–2007	0.004	17	17	non OECD
			(0.055)			
Expenditures, all	3-year average	1990–2007	0.043**	201	56	All
			(0.020)			
Expenditures, all	3-year average	1990–2007	0.033**	101	22	OECD
			(0.014)			
Expenditures, all	3-year average	1990–2007	0.042	100	34	non OECD
			(0.043)			
Expenditures, all	3-year average	1993–2007	0.046***	182	56	All
			(0.016)			
Expenditures, all	3-year average	1993–2007	0.039**	87	22	OECD
			(0.018)			
Expenditures, all	3-year average	1993–2007	0.048	95	34	non OECD
			(0.030)			
Expenditures, all	3-year average	1996–2007	0.048***	159	56	All
			(0.018)			
Expenditures, all	3-year average	1996–2007	0.024	70	22	OECD
			(0.023)			
Expenditures, all	3-year average	1996–2007	0.060*	89	34	non OECD
			(0.033)			
Expenditures, all[c]	3-year average	1990–2007	0.045**	201	56	All
			(0.020)			

Notes: Standard errors are clustered at the country level. ***, **, and * denote significance at the 1, 5, and 10 percent level, respectively. The subset of expenditures indicated with [a] contains compensation of employees, use of goods and services, and subsidies. The subset indicated with [b] contains compensation of employees, use of goods and services, and social benefits. Expenditures indicated with [c] are based on a dataset in which outliers are excluded, where outliers are defined as observations that lie outside the range of three times the standard deviation from the mean.

exception is the case where we average the data over the whole period and look at a pure cross-sectional analysis. In this case, the coefficient of fiscal decentralization is no longer significant. Shortening the time period to 1993–2007 and 1996–2007, respectively, and controlling for outliers does not affect the main results.

Some of these analyses are also performed for subsets of the sample, where we make a distinction between OECD member countries and other countries. In general, the coefficient of fiscal decentralization enters with a positive and significant, though a slightly lower point estimate, in the sample with OECD member countries only. Although fiscal decentralization sometimes enters with a significant coefficient in the sample with non OECD member countries, most of the time it is not significant. The evidence, thus, suggest that the relationship between fiscal decentralization and economic growth is more pronounced in OECD member countries.

3.5. Conclusions

This chapter analyzes the relationship between economic growth and fiscal decentralization. Using a sample of 56 countries over the period 1990–2007, we find that there is a positive relationship between fiscal decentralization economic growth. When excluding fiscal policy and trade related explanatory variables from the analyses, such as the size of the government and the openness of a country, we find no evidence of a relationship between economic growth and fiscal decentralization. The relationship holds both in the short run and long run, and seems to be more pronounced in OECD member countries. The use of alternative measures for fiscal decentralization may change these outcomes, which is the result of the accompanied changes in the samples rather than the use of the alternative measures themselves though.

To control for endogeneity problems, we introduced instrumental variables based on common legal system origin, common federal system, relative country size, and geographical distance. In contrast to the conventional instrumental variables in the literature, such as country size and legal system origin, our instrumental variables are time-variant, so they can be used in analyses where fiscal decentralization varies

over time. Although the same holds for the use of lags of fiscal decentralization as instrumental variables, our instruments have the advantage that they do not reduce the sample size and that it is possible to test for correlation with the error terms.

Our choice of instrumental variables is based on the notion that countries similar in aspects such as the origin of their legal system or country size have a similar process of fiscal decentralization. This idea implies that our approach may not work well for samples with a relatively small number of countries that are different in these aspects. One possible solution to this problem and direction for future research is the construction of a broader dataset of fiscal decentralization, covering a larger number of countries over a longer time period, that can be used to derive a general set of instrumental variables. Another direction for further research is to look at alternative aspects of countries that may be related to the process of fiscal decentralization such as the number of government tiers, number of local governments, or measures of autonomy.

Policy recommendations on fiscal decentralization may benefit from taking the outcomes of fiscal decentralization into account. The approach and instrumental variables suggested in this chapter help improve the evaluations of these outcomes by addressing possible reverse causality problems that may plague these assessments.

Appendix 3.A

Table A.1: Descriptive Statistics

Variable Name		Obs	Mean	St. Dev.	Min	Max
Growth rate real GDP per capita	overall	201	0.032	0.031	-0.124	0.126
	between			0.028	-0.006	0.122
	within			0.021	-0.121	0.088
Fiscal decentralization	overall	201	0.238	0.133	0.006	0.646
	between			0.144	0.015	0.634
	within			0.029	0.120	0.355
Initial real GDP per capita	overall	201	9.362	0.942	6.424	10.773
	between			1.026	6.424	10.773
	within			0	9.362	9.362
Population growth	overall	201	-2.880	0.161	-3.445	-2.397
	between			0.167	-3.379	-2.501
	within			0.048	-3.032	-2.690
Investment	overall	201	-1.538	0.200	-2.023	-0.871
	between			0.186	-1.878	-0.909
	within			0.106	-1.867	-1.189
Schooling	overall	201	-2.430	0.252	-3.973	-1.981
	between			0.265	-3.724	-2.014
	within			0.079	-2.910	-2.192
Federal system	overall	201	0.214	0.411	0	1
	between			0.401	0	1
	within			0	0.214	0.214
Government size	overall	201	-1.769	0.277	-2.736	-1.227
	between			0.259	-2.369	-1.293
	within			0.076	-2.252	-1.465
Trade openness	overall	201	0.886	0.478	0.180	3.020
	between			0.436	0.229	2.415
	within			0.133	0.346	1.491
OECD member countries	overall	201	0.502	0.501	0	1
	between			0.493	0	1
	within			0	0.502	0.502
East Asia & Pacific	overall	201	0.045	0.207	0	1
	between			0.227	0	1
	within			0	0.045	0.045
Eastern Europe & Central Asia	overall	201	0.264	0.442	0	1
	between			0.471	0	1
	within			0	0.264	0.264
Latin America & Caribbean	overall	201	0.114	0.319	0.000	1.000
	between			0.334	0.000	1.000
	within			0	0.114	0.114
Africa	overall	201	0.075	0.263	0	1
	between			0.312	0	1
	within			0	0.075	0.075

Notes: Based on the sample of 56 countries over the period 1990–2007. Data are 3 year averages, except for initial real GDP per capita and dummy variables. The exact definitions of the variables can be found in Section 3.3.1 and are too elaborate to describe here.

Table A.2: Data sources

	Variable name	Source	Series
g_{it}	Growth rate of real GDP per capita	WDI	GDP per capita, PPP (constant 2005 international $)
f_{it}	Fiscal decentralization	GFS	various
	Autonomy Indicators	OECD	OECD (1999; 2006; 2009)
$\ln y_{i0}$	Initial real GDP per capita	WDI	GDP per capita, PPP (constant 2005 international $)
$\boldsymbol{x}_{it}$	Population growth	WDI	Population, total
	Investment	WDI	Gross fixed capital formation (% of GDP)
	Schooling	WDI	School enrollment, secondary (% gross)
		UNESCO	Population share of secondary school age
$\boldsymbol{z}_{it}$	Federal system	paper[a]	Fan et al. (2009)
	Government size	WDI	WDI: General government final consumption expenditure (% of GDP)
	Trade openness	WDI	WDI: Trade (% of GDP)
	Regions	paper[b]	Easterly (2001)
	Legal Origin	paper[b]	Easterly (2001)
	Distance	CEPII	Simple distance (most populated cities, in kilometers)
	Size	WDI	Land area (square kilometers)

Notes: The exact definitions of the variables can be found in Section 3.3.1 and are too elaborate to describe here. Data sources are
WDI: `http://data.worldbank.org/indicator`
GFS: `http://www.imf.org/external/data.htm`
CEPII: `http://www.cepii.fr/anglaisgraph/bdd/distances.htm`
UNESCO: `http://www.uis.unesco.org/Pages/sitemap.aspx`
[a]: Data obtained from `http://www.sscnet.ucla.edu/polisci/faculty/treisman/index.html`
[b]: Data obtained from `http://go.worldbank.org/ZSQKYFU6J0`

Table A.3: Country Overview Samples

Endogeneity Sample			Autonomy Sample		
Argentina[a]	Finland[a]	Morocco	Australia[b]	Germany[b]	Norway[b]
Armenia	France[a]	Netherlands[a]	Austria[b]	Greece	Poland
Australia[a]	Georgia	New Zealand[a]	Belgium[b]	Hungary	Portugal
Austria[a]	Germany[a]	Norway[a]	Canada[b]	Iceland[b]	Spain[b]
Belarus	Greece[a]	Peru[a]	Czech Republic[b]	Italy[b]	Sweden[b]
Belgium[a]	Hungary[a]	Poland[a]	Denmark	Luxembourg[b]	Switzerland[b]
Bolivia[a]	Iceland[a]	Portugal[a]	Finland	Mexico[b]	United Kingdom
Bulgaria	Ireland[a]	Romania[a]	France[b]	Netherlands	
Canada[a]	Israel[a]	Russian Federation			
Chile[a]	Italy[a]	Slovak Republic[a]			
China	Kazakhstan[a]	Slovenia[a]			
Colombia	Latvia	South Africa[a]			
Congo, Rep.	Lesotho	Spain[a]			
Costa Rica	Lithuania[a]	Switzerland			
Croatia	Luxembourg[a]	Uganda[a]			
Czech Republic[a]	Malaysia[a]	Ukraine			
Denmark[a]	Mauritius	United Kingdom[a]			
El Salvador	Moldova	United States[a]			
Estonia[a]	Mongolia				

Notes: The endogeneity sample is used in Tables 3.4 and 3.6. Countries with the superscript *a* are also included in the corresponding reduced sample. The autonomy sample is used in Table 3.7. Countries with the superscript *b* are also included in the corresponding reduced sample.

Table A.4: Categories of Tax Autonomy

Label	Description	I	II	III
a	Discretion on rates and bases/reliefs	1.0	1.0	1.0
b1	Discretion on rates unrestricted	0.9	1.0	0
b2	Discretion on rates restricted	0.8	1.0	0
c	Discretion on bases/reliefs	0.7	0	0
d1	Tax sharing arrangement: Revenue split set by sub-national governments	0.6	0	0
d2	Tax sharing arrangement: Revenue split with consent of sub-national governments	0.5	0	0
d3	Tax sharing arrangement: Revenue split set by national government pluriannual	0.4	0	0
d4	Tax sharing arrangement: Revenue split set by national government biannual	0.3	0	0
e	Rates and bases/reliefs set by national government	0.2	0	0
f	Other	0.1	0	0

Notes: See OECD (1999) for a detailed description of the categories and procedures used to obtain the data.

4

Fiscal Policy Reforms and Dynamic Laffer Effects[1]

4.1. Introduction

The notion that the direct negative effect of a lower tax rate on government revenues is fully or partly offset by its stimulating effect on the economy has been around for quite some time and is best illustrated by the Laffer curve (Laffer, 1979). Recently, renewed attention has been paid to the impact of lower tax rates on government revenues in particular and to the impact of fiscal policy reforms on the government budget balance more generally. Feedback effects of changes in tax rates or public expenditures on the economy are now analyzed using dynamic rather than the traditional static frameworks.[2] In this chapter, we analyze the effects of several fiscal policy reforms on the long-run government budget balance using a dynamic general equilibrium framework. More specifically, we analyze the effect of changes in the capital income tax rate, the labor income tax rate, the consumption tax rate, and the public expenditures-to-output ratio on the long-run government budget balance in an endogenous growth framework. Moreover, we are interested in the conditions under which these fiscal policy reforms lead to a dynamic Laffer effect, which is defined as an improvement in the long-run government budget balance.

Our analysis is closely related to the work of Ireland (1994), Bruce and Turnovsky

[1] This chapter is based on Van Oudheusden (2009)

[2] For example, Fullerton (1982) analyzes the Laffer curve using a static framework.

(1999), Agell and Persson (2001), and Fernández et al. (2010) who all use a one-sector endogenous growth model to analyze the impact of changes in fiscal policy instruments on the long-run government budget balance in a closed economy.[3] These studies differ from each other in the assumptions made on the structure of government expenditures and public debt, leading to seemingly conflicting results and, therefore, a lack of consensus on the conditions under which a dynamic Laffer effect occurs.[4] Other related literature to our analysis is the work of Novales and Ruiz (2002) and Frederiksson (2007), who employ a two-sector rather than a one-sector endogenous growth model with elastic labor supply to analyze the effects of fiscal policy reforms on the economy. However, this choice for a two-sector model either restricts or makes an analytical analysis of the effects of fiscal policy reforms on the long-run government budget balance impossible.

We contribute to this literature in three ways. First, we can resolve the different results in the literature by decomposing the overall effect of fiscal policy reforms on the long-run government budget balance in three basic effects, namely the direct budget effect, the growth rate effect, and the discount rate effect.[5] In addition, we take different specifications with respect to the structure of government expenditures and public debt into account. Second, by assuming labor supply to be endogenous instead of exogenous, we include a labor-leisure trade-off which allows us to study a wider variety of fiscal policy reforms. That is, changes in the labor income tax rate and the consumption tax rate now have real effects instead of acting as lump-sum taxes. Third, we calibrate the model for some of the euro area economies and analyze a wide array of fiscal policy reforms to see whether a dynamic Laffer effect occurs. Rather than restricting attention to marginal changes in fiscal instruments available to the government, we look at discrete changes. Moreover, we separately

[3]Mankiw and Weinzierl (2006) and Trabandt and Uhlig (2011) analyze the effects of fiscal policy reforms on the long-run government budget balance in a framework in which the growth rate of the economy is exogenously given and cannot be permanently affected by changes in fiscal instruments. Therefore, their approach is quite different from ours.

[4]The different conditions under which a dynamic Laffer effect occurs in the literature will be discussed in Section 4.3.3.

[5]The direct budget effect covers the direct impact of fiscal policy reforms on government revenues and expenditures, the growth rate effect, covers the impact on government revenues and expenditures over time, and the discount rate effect aligns the changes in current and future government revenues and expenditures.

analyze the effects of allowing for changes in labor supply and different assumptions on government debt so that we can quantify their impact on the analysis of dynamic Laffer effects.

Our results are as follows. We analytically explain and reconcile the seemingly different results found in the literature on dynamic Laffer effects. In addition to the current explanation, which is an assumption about the structure of government expenditures provided by Agell and Persson (2001), an assumption about public debt is needed to explain these different results. Hence, we find that the current explanation has to be altered. Moreover, the decomposition of the overall effect enables us to identify the necessary conditions under which a dynamic Laffer effect can occur. However, numerical analyses are required to see whether such an effect actually occurs.

Using numerical illustrations, we show that for an economy representative of the euro area a dynamic Laffer effect is always obtained for lower tax rates on capital income. An improvement in the long-run government budget balance may be possible for a lower tax rate on labor income or a higher public expenditures-to-output ratio though this requires substantial and unrealistic changes in these fiscal instruments. These findings, however, depend on the economy considered and the assumptions made. For example, when looking at Spain, a lower tax rate on capital income does not lead to a dynamic Laffer effect when allowing for changes in labor supply and taking into account the initial stock of public debt. Relaxing some of these assumptions change the analysis so that a dynamic Laffer effect may be possible for Spain. We find that neglecting the stock of initial debt or changes in labor supply lead to an overestimation and underestimation of the dynamic Laffer effect, respectively.

The assumption of a fixed path of lump-sum transfers is crucial for any of these dynamic Laffer effects to occur. When relaxing this assumption, we show that financing lower tax rates on factor income by a higher tax rate on consumption gives combinations of tax rates that lead to an improvement in both the long-run government budget balance and welfare. When the tax rate on capital income is lowered, these combinations of tax rates lead to a decrease in labor supply and

negative immediate welfare effects. However, when the tax rate on labor income is lowered, these combinations of tax rates lead to an increase in labor supply and positive immediate welfare effects. In both cases, feasible combinations are not found for marginal changes in tax rates but are found for discrete changes only.

The remainder of the chapter is structured as follows. Section 2 discusses the analytical framework. Section 3 discusses the analytical results, consisting of comparative static effects of changes in fiscal policy instruments, the effects on the long-run government budget balance, and an explanation of the different results in the literature. Section 4 discusses the calibration and presents numerical results. Section 5 concludes.

4.2. Analytical Framework

The closed economy is characterized by three economic actors, namely firms, households, and the government, which are discussed in turn.

4.2.1. Firms

The production side of the economy is characterized by a continuum of identical firms operating under perfect competition. For convenience, the total number of firms is normalized to unity. Following Benhabib and Farmer (1994), the production technology for firm i is given by

$$Y_i(t) = K_i(t)^a L_i(t)^b X(t), \qquad a + b = 1,$$
$$X(t) = \bar{K}(t)^{\alpha - a} \bar{L}(t)^{\beta - b}, \qquad a < \alpha \leq 1,\ b < \beta < 1,\ \alpha + \beta > 1,$$

where $Y_i(t)$ is output of firm i, and the production factors $K_i(t)$ and $L_i(t)$ represent the private capital stock and the amount of labor used by firm i, respectively. From the perspective of the representative firm, the Cobb-Douglas production technology exhibits constant returns to scale, that is $a+b=1$. The term $X(t)$ represents positive external returns that are increasing in the economy-wide average levels of the capital stock $\bar{K}(t)$ and amount of labor $\bar{L}(t)$. Output is taken as the numeraire, and the corresponding price is normalized to unity.

The stock market value of firm i is given by the present value of current and future cash flows:

$$V_i(0) \equiv \int_0^\infty \left[Y_i(t) - w(t)L_i(t) - I_i(t)\right] e^{-\int_0^t r(s)ds} dt,$$

where $r(t)$ is the rate of return to capital, $w(t)$ is the wage rate, and $I_i(t)$ is gross investment, all denoted in real terms. Firms maximize their stock market value subject to the capital accumulation constraint $\dot{K}_i(t) = I_i(t) - \delta K_i(t)$, where δ is the depreciation rate. In equilibrium it holds that $K_i(t) = \bar{K}(t) = K(t)$, $L_i(t) = \bar{L}(t) = L(t)$, and $Y_i(t) = \bar{Y}(t) = Y(t)$. We assume that capital externalities are large enough for the aggregate production technology to be linear in capital so that

$$Y(t) = K(t)L(t)^\beta. \tag{4.1}$$

Competitive factor payments, resulting from the maximization problem of the firm, are given by

$$r(t) = aL(t)^\beta - \delta, \tag{4.2}$$

$$w(t) = bK(t)L(t)^{\beta-1}. \tag{4.3}$$

On the production side of the economy, we abstract from human capital as a factor of production. Taking it into account comes with serious problems for the purpose of our analysis. First, including it according to Novales and Ruiz (2002) makes the model analytically intractable. This means we cannot use our model to reconcile the different results in the literature. Frederiksson (2007) partly solves this problem by putting restrictions on the accumulation functions of physical and human capital. Under these restrictions, he shows there are both static and dynamic inefficiencies that have to be taken into account when analyzing the effect of fiscal policy reforms on the budget balance of the government. However, the specification of Frederiksson (2007) limits the calibration of the model, especially when endogenous labor supply is taken into account. Since we want to explain the different result in the literature, want to include endogenous labor supply to prevent non-distorting

taxation, and want as few limitations as possible for the calibration of our model, we do not include human capital as a production factor in our production technology. Basically, this analytical framework is the simplest one possible that can be used to explore the mechanisms behind the dynamic Laffer effect while still being able to replicate basic stylized facts observed in the data.

4.2.2. Households

Infinitely lived representative households have identical and time separable preferences, and lifetime utility is given by

$$\Lambda(0) \equiv \int_0^{\infty} U(t)e^{-\rho t}dt, \quad \rho > 0, \tag{4.4}$$

where ρ is the pure rate of time preference and $U(t)$ represents the felicity function:[6]

$$U(t) \equiv \frac{[C(t)^{\phi}(1-L(t))^{\eta}G(t)^{\theta}]^{1-\sigma}-1}{1-\sigma} \quad \text{if} \quad \sigma \neq 1,$$

where $C(t)$ is private goods consumption, and $G(t)$ is public goods consumption. Leisure is represented by $1-L(t)$, where the amount of time available to the households has been normalized to unity. The parameter $\sigma > 0$ represents the inverse of the intertemporal elasticity of substitution. Preferences for private goods consumption, leisure, and public goods consumption are non-separable, and their respective weights are given by $\phi > 0$, $\eta > 0$, and $\theta \geq 0$. Moreover, the felicity function is assumed to be jointly concave in private goods consumption, public goods consumption, and leisure, resulting in the following constraints on the preferences' weights:

$$1-(1-\sigma)\phi > 0, \quad 1-(1-\sigma)(\phi+\eta) > 0, \quad \text{and} \quad 1-(1-\sigma)(\phi+\theta) > 0. \tag{4.5}$$

If $\theta = 0$, then public goods consumption is modeled as waste, and $\theta > 0$ means the provision of public goods by the government is utility enhancing. Since we assume preferences for private and public goods to be non-separable, the utility weight of public goods consumption enters the inverse of the effective intertemporal

[6] $U(t) \equiv \phi \log C(t) + \eta \log[1-L(t)] + \theta \log G(t)$ if $\sigma = 1$.

elasticity of substitution, $1-(1-\sigma)(\phi+\theta)$, and therefore affects the dynamics of the model quantitatively; see also Section 4.2.4. Alternatively, preferences for private and public goods can be assumed to be additively separable by assuming that $\theta = 0$. The main results of the chapter are not affected by these choices though; see also Agell and Persson (2001).

Households receive income from labor and claims on both physical capital and government bonds. Following Turnovsky (2000b), government bonds are assumed to be perpetuities that every period pay out a coupon equal to one unit of output. The nominal value of the stock of bonds held by the households is denoted by $B(t)$, which is defined as the number of bonds multiplied by their price $p(t)$, where this price is defined in terms of the numeraire.[7] Households receive lump-sum transfers from the government, which we denote by $T(t) > 0$. The budget constraint of the household is then given by

$$\dot{K}(t)+\dot{B}(t) = (1-\tau_A)r(t)K(t)+(1-\tau_A)q(t)B(t)+(1-\tau_L)w(t)L(t)-(1+\tau_C)C(t)+T(t), \quad (4.6)$$

where $q(t)$ is the rate of return on government bonds and is defined as $q(t) = \frac{1+\dot{p}(t)}{p(t)}$. Income of households is taxed, where τ_A and τ_L denote the tax rates on capital income and labor income, respectively. Moreover, private goods consumption is taxed where τ_C is the corresponding *ad valorem* tax rate. Note that these tax rates are assumed to be time invariant in equilibrium. Households choose private goods consumption, labor, capital, and government bonds to maximize utility (4.4) subject to the budget constraint (4.6). The first-order conditions for this problem are

$$[C(t)^{\phi}(1-L(t))^{\eta}G(t)^{\theta}]^{1-\sigma}\phi C(t)^{-1} = \lambda(t)(1+\tau_C), \quad (4.7a)$$

$$[C(t)^{\phi}(1-L(t))^{\eta}G(t)^{\theta}]^{1-\sigma}\eta(1-L(t))^{-1} = \lambda(t)w(t)(1-\tau_L), \quad (4.7b)$$

$$\rho - \frac{\dot{\lambda}(t)}{\lambda(t)} = (1-\tau_A)r(t), \quad (4.7c)$$

$$\rho - \frac{\dot{\lambda}(t)}{\lambda(t)} = (1-\tau_A)q(t), \quad (4.7d)$$

[7] This specification allows for immediate adjustment of the price of bonds such that constant portfolio shares of physical capital and government bonds in equilibrium are guaranteed. Hence, the specification abstracts from transitional dynamics in portfolio shares associated with fixed-price bonds, see Turnovsky (2000b, p. 438).

where $\lambda(t)$ is the shadow price of assets. The transversality conditions are given by

$$\lim_{t\to\infty} \lambda(t)K(t)e^{-\rho t} = 0, \quad \text{and} \quad \lim_{t\to\infty} \lambda(t)B(t)e^{-\rho t} = 0. \tag{4.8}$$

Combining equations (4.7c) and (4.7d) gives the no-arbitrage equation $r(t) = q(t)$, which implies that the return on physical capital should equal the return on government bonds.

4.2.3. Government

To link the provision of public goods to the size of the economy, the government uses a constant fraction ω_G of output for the provision of unproductive public goods:

$$G(t) = \omega_G Y(t), \qquad 0 < \omega_G < 1. \tag{4.9}$$

Besides the provision of public goods for consumption, government expenditures are interest payments on outstanding bonds and lump-sum transfers to households. Revenues of the government consist of taxes on capital income, labor income, and private goods consumption. Any fiscal deficit has to be financed by issuing bonds. Taking into account the no-arbitrage condition $r(t) = q(t)$, the budget constraint of the government becomes

$$\dot{B}(t) = \omega_G Y(t) + T(t) + (1-\tau_A)r(t)B(t) - \tau_A r(t)K(t) - \tau_L w(t)L(t) - \tau_C C(t). \tag{4.10}$$

4.2.4. The Balanced Growth Path

The equilibrium of the decentralized equilibrium is characterized by a first-order differential equation in labor supply, which is obtained by a number of steps.[8] We make use of the intratemporal optimality condition between leisure and private goods consumption that can readily be obtained by dividing (4.7a) by (4.7b):

$$\frac{C}{1-L}\frac{\eta}{\phi} = \frac{1-\tau_L}{1+\tau_C}w, \tag{4.11}$$

[8] In the derivations we omit time indices for convenience of notation.

which implies that at each point in time the marginal rate of substitution between leisure and private goods consumption should equal its relative price. We also make use of the aggregate resource constraint that follows from combining the budget constraint of the household (4.6) and the budget constraint of the government (4.10):

$$\dot{K} = rK + wL - C - G = (1 - \omega_G)Y - \delta K - C, \tag{4.12}$$

where we have used (4.1)–(4.3), (4.9), and $a + b = 1$ in deriving (4.12). The set of equations that is used to derive the first-order differential equation in labor supply is given by[9]

$$\frac{\dot{L}}{L} = \left[((1-\sigma)\phi - 1)\frac{\dot{C}}{C} + (1-\sigma)\theta\frac{\dot{K}}{K} - \frac{\dot{\lambda}}{\lambda}\right]\left[(1-\sigma)\eta\frac{L}{1-L} - (1-\sigma)\theta\beta\right]^{-1}, \tag{4.13a}$$

$$\frac{\dot{C}}{C} = \left[-\frac{L}{1-L} + \beta - 1\right]\frac{\dot{L}}{L} + \frac{\dot{K}}{K}, \tag{4.13b}$$

$$\frac{\dot{K}}{K} = \left[1 - \omega_G - \frac{1-\tau_L}{1+\tau_C}\frac{b\phi}{\eta}\frac{1-L}{L}\right]L^{\beta} - \delta, \tag{4.13c}$$

$$\frac{\dot{\lambda}}{\lambda} = \rho - (1-\tau_A)(aL^{\beta} - \delta). \tag{4.13d}$$

By substituting equations (4.13b), (4.13c), and (4.13d) into equation (4.13a), we obtain the expression for the first-order differential equation in labor supply:

$$\frac{\dot{L}}{L} = \frac{\Theta^N(L)}{\Theta^D(L)}, \tag{4.14}$$

where

$$\Theta^N(L) \equiv \left[\left(1 - \omega_G - \frac{1-\tau_L}{1+\tau_C}\frac{b\phi}{\eta}\frac{1-L}{L}\right)L^{\beta} - \delta\right]\left[(1-\sigma)(\phi+\theta) - 1\right] + (1-\tau_A)(aL^{\beta} - \delta) - \rho, \tag{4.15a}$$

$$\Theta^D(L) \equiv -\left[1 - (1-\sigma)(\phi+\eta)\right]\frac{L}{1-L} + \beta\left[1 - (1-\sigma)(\phi+\theta)\right] - \left[1 - (1-\sigma)\phi\right]. \tag{4.15b}$$

[9] Substituting (4.1) and (4.9) into (4.7a) and subsequently taking the logarithm and time derivate of the resulting expression gives equation (4.13a). Substituting (4.3) into (4.11) and subsequently taking the logarithm and time derivate of the resulting expression gives equation (4.13b). Equation (4.13c) is obtained by dividing both sides of (4.12) by K and making use of the expression of the consumption-capital ratio. The latter can be obtained by substituting (4.3) into (4.11) and rearranging terms. Finally, substituting (4.2) into (4.7d) and rearranging terms gives equation (4.13d).

We define the balanced growth path as a situation in which private goods consumption, physical capital, and output grow at the same rate which is given by $\gamma \equiv \frac{\dot{C}}{C} = \frac{\dot{K}}{K} = \frac{\dot{Y}}{Y}$. However, along the balanced growth path, labor supply is constant: $\dot{L} = 0$. Equation (4.14) then implies that $\Theta^N(L) = 0$ must hold. This is the case if

$$\frac{(1-\tau_A)(aL^\beta - \delta) - \rho}{1-(1-\sigma)(\phi+\theta)} = \left[1 - \omega_G - \frac{1-\tau_L}{1+\tau_C}\frac{b\phi}{\eta}\frac{1-L}{L}\right] L^\beta - \delta. \tag{4.16}$$

We follow Turnovsky (2000a) and represent the balanced growth path by two loci describing the relationship between the growth rate and labor supply. The left-hand side of (4.16) is associated with portfolio balance equilibrium and the right-hand side of (4.16) with product market equilibrium. These are given by

$$\gamma_P(L) \equiv \frac{(1-\tau_A)(aL^\beta - \delta) - \rho}{1-(1-\sigma)(\phi+\theta)}, \tag{4.17a}$$

$$\gamma_Q(L) \equiv \left[1 - \omega_G - \frac{1-\tau_L}{1+\tau_C}\frac{b\phi}{\eta}\frac{1-L}{L}\right] L^\beta - \delta. \tag{4.17b}$$

The effect of assuming preferences for private and public goods consumption to be non-separable can be seen in the denominator of equation (4.17a), which is the standard Euler equation. Assuming $\theta > 0$ only affects the value of the effective intertemporal elasticity of substitution, given by $\frac{1}{1-(1-\sigma)(\phi+\theta)}$, but does not affect the main results of the chapter since it is always larger than zero regardless of the value of θ; see equation (4.5).

It can be shown that an equilibrium exists if

$$\sigma > 1 - \frac{1 - \omega_G - (a-\delta)(1-\tau_A) + \rho}{(1-\omega_G)(\phi+\theta)}, \tag{4.18a}$$

and that this equilibrium is unique. Moreover, the equilibrium is determinate, or locally unstable, if

$$\Theta^D(\tilde{L}) < 0, \tag{4.18b}$$

where $\tilde{L}$ is the level of labor supply for which (4.16) holds. See Appendix 4.A.1 and 4.A.2 for a derivation of both these results. We assume that the conditions in (4.18)

are always satisfied so that both a unique equilibrium exists and the economy always lies on its balanced growth path. Since the production technology is similar to that of Benhabib and Farmer (1994), an equilibrium may exist that is indeterminate, or locally stable. However, both equation (4.18a) and equation (4.18b) hold when performing the numerical analyses in Section 4.4. The same holds for the transversality conditions (4.8) which are satisfied if $\rho > (1-\sigma)(\phi+\theta)\gamma$. We therefore focus on the determinate equilibrium only but do indicate how results may change in the case the equilibrium is indeterminate.

4.3. Analytical Results

We first discuss comparative static effects that we use to decompose the dynamic Laffer effect in three basic effects. These basic effects are used to identify the necessary conditions for a dynamic Laffer effect to occur and to reconcile the different results in the literature.

4.3.1. Comparative Static Effects

Fiscal policy reforms are defined as changes in the fiscal policy instruments τ_A, τ_L, τ_C, or ω_G. Their effects on labor supply are obtained by fully differentiating (4.16). To keep the government budget balanced, we assume changes in government expenditures or revenues as a result of fiscal policy reforms to be offset in a non-distorting way via changes in lump-sum transfers. The effects are given by

$$sgn\left\{\frac{d\tilde{L}}{d\tau_A}\right\} = sgn\left\{\frac{d\tilde{L}}{d\tau_L}\right\} = sgn\left\{\frac{d\tilde{L}}{d\tau_C}\right\} < 0, \qquad sgn\left\{\frac{d\tilde{L}}{d\omega_G}\right\} > 0. \tag{4.19a}$$

Effects of fiscal policy reforms on the growth rate of the economy are obtained by fully differentiating (4.17a) and are given by

$$sgn\left\{\frac{d\gamma(\tilde{L})}{d\tau_A}\right\} = sgn\left\{\frac{d\gamma(\tilde{L})}{d\tau_L}\right\} = sgn\left\{\frac{d\gamma(\tilde{L})}{d\tau_C}\right\} < 0, \qquad sgn\left\{\frac{d\gamma(\tilde{L})}{d\omega_G}\right\} > 0. \tag{4.19b}$$

If the equilibrium is indeterminate, which is not supported by the calibration in Section 4.4, these results are reversed; see also Itaya (2008). See Appendix 4.A.3

for a derivation of these results. From (4.19a) and (4.19b) it is clear that both labor supply and the growth rate of the economy decrease with higher tax rates and increase with a higher public expenditures-to-output ratio. We proceed by discussing the effects of changes in fiscal policy instruments on the growth rate separately.

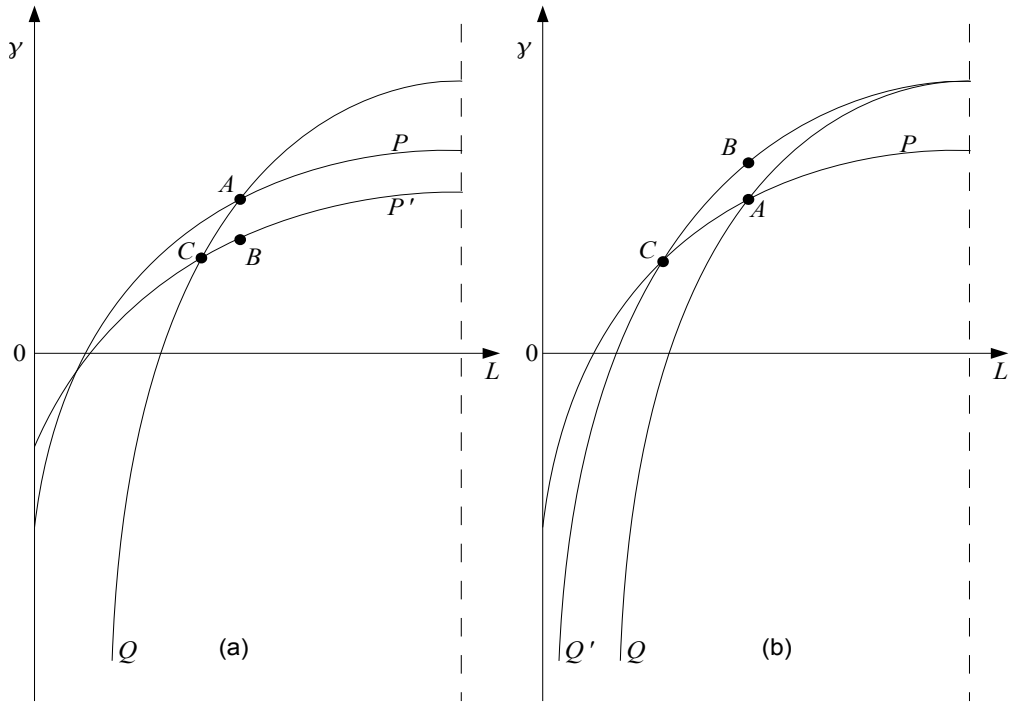
The effect of a higher capital income tax rate on economic growth is given in panel (a) of Figure 4.1 and is represented by a rotation of the line associated with portfolio balance equilibrium from P to P'. Holding labor supply fixed, a higher tax rate on capital income lowers the after-tax return on capital so that it falls below the return on consumption.[10] This difference, in terms of the growth rate, is given by the vertical distance between A and B. Consequently, households respond by increasing private goods consumption. At the same time, households increase leisure to ensure the intratemporal optimality condition between leisure and private goods consumption remains satisfied. The resulting fall in labor supply has a negative effect on the growth rate. The overall effect is given by the shift from A to C along the line Q.

The effect of a higher labor income tax rate or consumption tax rate on economic growth is given in panel (b) of Figure 4.1 and is represented by a rotation of the line associated with product market equilibrium from Q to Q'. Both a higher labor income tax rate and a higher consumption tax rate make private goods consumption relatively expensive compared to leisure. Holding labor supply fixed, households respond by lowering private goods consumption to retain the intratemporal optimality condition between leisure and private goods consumption. This decrease in consumption for a given amount of labor supply leads to a rise in the return to consumption above the return to investment. In terms of the growth rate, this difference is given by the vertical distance between A and B.[11] Households respond by both increasing private goods consumption and leisure. The resulting fall in labor supply has a negative effect on the growth rate. The overall effect is given by the shift from A to C along the line P.

[10] The return on private goods consumption is given by the left-hand side of (4.7c) and (4.7d); see Turnovsky (2000b, p. 233) for an explanation of the return on consumption.

[11] Holding labor supply fixed, there is too little investment given the the return to investment when the public expenditures-to-output ratio increases since the intratemporal optimality condition between leisure and private goods consumption is not affected. The effect is thus the opposite of a higher labor income tax rate or consumption tax rate.

Figure 4.1: Growth Rate Effects of Changes in Fiscal Policy Instruments



4.3.2. Three Basic Effects on the Long-run Government Budget Balance

The comparative static effects are used to analyze changes in the long-run government budget balance. The long-run government budget balance is given by the intertemporal budget constraint of the government, which can be obtained by integrating (4.10) and making use of the customary No-Ponzi Game condition given by $\lim_{t\to\infty} B(t)e^{-(1-\tau_A)(aL^\beta-\delta)t} = 0$. The intertemporal budget constraint of the government is given by

$$\Delta \equiv \underbrace{\frac{\tau_A(a\tilde{L}^\beta-\delta)K(0)+\tau_L bK(0)\tilde{L}^\beta+\tau_C C(0)}{(1-\tau_A)(a\tilde{L}^\beta-\delta)-\tilde{\gamma}}}_{\text{present value of revenues}} - \underbrace{\frac{\omega_G K(0)\tilde{L}^\beta+T(0)}{(1-\tau_A)(a\tilde{L}^\beta-\delta)-\tilde{\gamma}}}_{\text{present value of expenditures}} - B(0) = 0, \quad (4.20)$$

where initially it is balanced: $\Delta = 0$.[12] When deriving the intertemporal budget constraint of the government, we assume lump-sum transfers to grow at the same rate as the economy. Choosing lump-sum transfers to grow at a different growth rate than the economy implies that in the long run the size of transfers will become

[12] $\tilde{\gamma}$ is the growth rate valued at $\tilde{L}$.

either very small or very large compared to output.

To explore the mechanisms behind the dynamic Laffer effect, we distinguish three basic effects when analyzing the overall effect of fiscal policy reforms on the long-run government budget balance: (i) the *direct budget effect*, covering the direct impact of fiscal policy reforms on government revenues and expenditures; (ii) the *growth rate effect*, covering the impact on government revenues and expenditures over time; and (iii) the *discount rate effect*, aligning the changes in current and future government revenues and expenditures. The basic effects are obtained by fully differentiating (4.20) with respect to the policy instrument of choice:

$$\frac{d\Delta}{di} = \Delta_i = \xi_i + \xi_i^l + \upsilon_i + \upsilon_i^l + \pi_i + \pi_i^l - \zeta_i - \zeta_i^l, \tag{4.21}$$

where ξ_i, υ_i, and π_i, for $i \in \{\tau_A, \tau_L, \tau_C, \omega_G\}$, represent the direct budget effect, the discount rate effect, and the growth rate effect, respectively. The growth rate effect for lump-sum government transfers in particular is represented by ζ_i for $i \in \{\tau_A, \tau_L, \tau_C, \omega_G\}$. Although the effect of ζ is implicitly captured by π, we include it in our analysis to emphasize the main assumption responsible for the dynamic Laffer effects found in the literature. This assumption will be discussed in Section 4.3.2.2. The superscript l represents the part of the basic effects that is caused by changes in labor supply only. The basic effects are discussed in turn.[13]

4.3.2.1. The Direct Budget Effect

Ignoring changes in labor supply for the moment, the direct budget effect is given by

$$\xi_{\tau_A} \equiv \frac{(a\tilde{L}^\beta - \delta)K(0)}{(1-\tau_A)(a\tilde{L}^\beta - \delta) - \tilde{\gamma}} \left[1 + \frac{\tau_C}{1-(1-\sigma)(\phi+\theta)}\right] > 0, \tag{4.22a}$$

$$\xi_{\tau_L} \equiv \frac{bK(0)\tilde{L}^\beta}{(1-\tau_A)(a\tilde{L}^\beta - \delta) - \tilde{\gamma}} > 0, \tag{4.22b}$$

$$\xi_{\tau_C} \equiv \frac{\tilde{C}(0)}{(1-\tau_A)(a\tilde{L}^\beta - \delta) - \tilde{\gamma}} > 0, \tag{4.22c}$$

$$\xi_{\omega_G} \equiv -\frac{K(0)\tilde{L}^\beta}{(1-\tau_A)(a\tilde{L}^\beta - \delta) - \tilde{\gamma}} [1+\tau_C] < 0. \tag{4.22d}$$

[13]Hereby we make use of the expression for initial private consumption $\tilde{C}(0) = [(1-\omega_G)\tilde{L}^\beta - (\tilde{\gamma}+\delta)]K(0)$, which follows from the relationship between the growth rate and labor supply associated with product market equilibrium; see (4.17b).

The bracketed terms in equations (4.22a) and (4.22d) indicate that changes in fiscal policy instruments not only affect their own tax base but also other tax bases. For example, a lower tax rate on capital income increases the firm's incentives to invest, which come at the cost of lower private goods consumption. A higher public expenditures-to-output ratio crowds out private goods consumption directly. Both effects lead to a decrease in the consumption tax base, which in turn leads to a deterioration of the long-run government budget balance. The additional effect caused by changes in labor supply is given by

$$\xi_i^l \equiv \frac{\tau_A a + \tau_L b + \tau_C \left[1 - \omega_G - \frac{(1-\tau_A)a}{1-(1-\sigma)(\phi+\theta)}\right] - \omega_G}{(1-\tau_A)(a\tilde{L}^\beta - \delta) - \tilde{\gamma}} \beta K(0) \tilde{L}^{\beta-1} \frac{d\tilde{L}}{di} \gtrless 0, \tag{4.23}$$

for $i \in \{\tau_A, \tau_L, \tau_C, \omega_G\}$. A change in labor supply resulting from a fiscal policy reform not only affects government revenues via changes in tax bases but also affects government expenditures since the latter are linked to the size of the economy; see (4.9). The net effect is given by the numerator of equation (4.23), which has to be determined numerically. The direct budget effect is thus ambiguous.

4.3.2.2. The Growth Rate Effect

Again ignoring changes in labor supply for the moment, the growth rate effect is given by

$$\pi_{\tau_A} \equiv -B(0) \frac{(a\tilde{L}^\beta - \delta)}{[(1-\tau_A)(a\tilde{L}^\beta - \delta) - \tilde{\gamma}]} \frac{1}{[1-(1-\sigma)(\phi+\theta)]}, \tag{4.24a}$$

and $\pi_{\tau_L} \equiv \pi_{\tau_C} \equiv \pi_{\omega_G} \equiv 0$. The additional effect caused by changes in labor supply is given by

$$\pi_i^l \equiv B(0) \frac{(1-\tau_A)a\beta\tilde{L}^{\beta-1}}{[(1-\tau_A)(a\tilde{L}^\beta - \delta) - \tilde{\gamma}]} \frac{1}{[1-(1-\sigma)(\phi+\theta)]} \frac{d\tilde{L}}{di}, \tag{4.24b}$$

for $i \in \{\tau_A, \tau_L, \tau_C, \omega_G\}$. When labor supply does not change, the effect is absent for τ_L, τ_C, and ω_G so that endogenous labor supply is necessary for the growth rate effect to extend to these instruments. More importantly, the sign of the growth rate effect depends on the initial stock of public debt: $B(0)$. The intuition for this relationship

is as follows. When the initial stock of public debt is positive $B(0) > 0$, the present value of revenues is larger than the present value of expenditures so that, given the discount rate, there is a stream of positive cash flows. Now, consider a fiscal policy reform that leads to a higher growth rate. The stream of positive cash flows then grows at a higher rate than before the fiscal policy reform, which corresponds to an improvement in the long-run government budget balance.

The growth rate effect corresponding to lump-sum government transfers is given by

$$\zeta_{\tau_A} \equiv \frac{T(0)(a\tilde{L}^{\beta} - \delta)}{[1-(1-\sigma)(\phi+\theta)][(1-\tau_A)(a\tilde{L}^{\beta} - \delta) - \tilde{\gamma}]^2}, \tag{4.25a}$$

and $\zeta_{\tau_L} \equiv \zeta_{\tau_C} \equiv \zeta_{\omega_G} \equiv 0$ when labor supply does not change. The additional effect caused by changes in labor supply is given by

$$\zeta_i^l \equiv -\frac{T(0)(1-\tau_A)a\beta\tilde{L}^{\beta-1}}{[1-(1-\sigma)(\phi+\theta)][(1-\tau_A)(a\tilde{L}^{\beta} - \delta) - \tilde{\gamma}]^2}\frac{d\tilde{L}}{di}, \tag{4.25b}$$

for $i \in \{\tau_A, \tau_L, \tau_C, \omega_G\}$. Again, consider a fiscal policy reform that leads to a higher growth rate. Lump-sum transfers, from the perspective of the government seen as a stream of negative cash flows, then grow at a higher rate than before the fiscal policy reform, which corresponds to a deterioration in the long-run government budget balance.

We pay special attention to the growth rate effect corresponding to lump-sum government transfers since it is directly connected to the main assumption made in the literature. This assumption is that the path of lump-sum transfers is predetermined, and it is made by Ireland (1994), Agell and Persson (2001), Novales and Ruiz (2002), Frederiksson (2007), and Fernández et al. (2010). It means that after a fiscal policy reform lump-sum transfers remain to grow at the rate corresponding to the old equilibrium so that the growth rate effect corresponding to lump-sum government transfers is left out of the analysis. Since this effect is negative for a growth promoting fiscal policy reform, it is more likely to obtain a dynamic Laffer effect when this assumption is made.

4.3.2.3. The Discount Rate Effect

The discount rate effect has a similar structure to that of the growth rate effect and is given by

$$\upsilon_{\tau_A} \equiv B(0)\frac{a\tilde{L}^{\beta} - \delta}{(1-\tau_A)(a\tilde{L}^{\beta} - \delta) - \tilde{\gamma}}, \tag{4.26a}$$

and $\upsilon_{\tau_L} \equiv \upsilon_{\tau_C} \equiv \upsilon_{\omega_G} \equiv 0$ when labor supply does not change. The additional effect caused by changes in labor supply is given by

$$\upsilon_i^l \equiv -B(0)\frac{(1-\tau_A)a\beta\tilde{L}^{\beta-1}}{(1-\tau_A)(a\tilde{L}^{\beta} - \delta) - \tilde{\gamma}}\frac{d\tilde{L}}{di}, \tag{4.26b}$$

for $i \in \{\tau_A, \tau_L, \tau_C, \omega_G\}$. As for the growth rate effect, the sign of the discount rate effect depends on the initial stock of public debt. However, the intuition for this relationship is different than that of the growth rate effect. Recall that a positive initial stock of public debt corresponds to a stream of positive cash flows. A fiscal policy reform that leads to an increase in labor supply implies a higher discount rate. The stream of positive cash flows is now discounted at a higher rate, which leads to a lower present value and thus to a deterioration in the long-run government budget balance. Again, endogenous labor supply is necessary for the discount rate effect to extend to all fiscal policy instruments.

4.3.2.4. The Overall Effect

We now look at the overall effect where, for analytical tractability, we take the discount rate effect and the growth rate effect together. More specifically, we replace $\upsilon_i + \upsilon_i^l + \pi_i + \pi_i^l$ in equation (4.21) by the equations in (4.24) and (4.26) so that the overall effect is given by

$$\begin{aligned}\Delta_i = {} & \xi_i + \xi_i^l - \zeta_i - \zeta_i^l \\ & + B(0)\frac{(a\tilde{L}^{\beta} - \delta)}{(1-\tau_A)(a\tilde{L}^{\beta} - \delta) - \tilde{\gamma}}\left[1 - \frac{1}{1-(1-\sigma)(\phi+\theta)}\right] \\ & - B(0)\frac{(1-\tau_A)a\beta\tilde{L}^{\beta-1}}{(1-\tau_A)(a\tilde{L}^{\beta} - \delta) - \tilde{\gamma}}\left[1 - \frac{1}{1-(1-\sigma)(\phi+\theta)}\right]\frac{d\tilde{L}}{di},\end{aligned} \tag{4.27}$$

for $i = \tau_A$, and

$$\Delta_i = \xi_i + \xi_i^l - \zeta_i - \zeta_i^l - B(0)\frac{(1-\tau_A)a\beta\tilde{L}^{\beta-1}}{(1-\tau_A)(a\tilde{L}^{\beta}-\delta)-\tilde{\gamma}}\left[1-\frac{1}{1-(1-\sigma)(\phi+\theta)}\right]\frac{d\tilde{L}}{di}, \tag{4.28}$$

for $i \in \{\tau_L, \tau_C, \omega_G\}$. In equations (4.27) and (4.28), the first term between brackets corresponds to the discount rate effect, and the second term between brackets corresponds to the growth rate effect. The discount rate effect dominates the growth rate effect if the bracketed term is positive. The reverse holds if it is negative, and both effects cancel out when it is zero. The sign of the bracketed term is determined by the intertemporal elasticity of substitution: $1/\sigma$. When it is relatively high so that $\sigma < 1$, households are more willing to shift consumption between time periods, and the growth rate effect dominates. When it is relatively low so that $\sigma > 1$, households are less willing to shift consumption between time periods, and the discount rate effect dominates. Table 4.1 gives an overview of all of the above discussed effects for a number of fiscal policy reforms in a convenient manner.

4.3.3. Explaining the Literature

The first row of Table 4.1, $(d\tau_A < 0)$, is used to reconcile the conflicting results in the literature. These conflicting results are as follows. Ireland (1994) shows that a dynamic Laffer effect is obtained for both $\sigma > 1$ and $\sigma < 1$, while Bruce and Turnovsky (1999) show that this is only possible for $\sigma < 1$. Agell and Persson (2001) show that a dynamic Laffer effect does not exist at all for any σ and argue that all these differences are explained by the assumption made on the path of government expenditures. We think this explanation has to be altered.

The analysis of Ireland (1994) is replicated by setting $B(0) = 0$ and noting that the path of lump-sum transfers is assumed to be predetermined. Since labor supply is exogenous, the overall effect of his analysis is given by the sign of $\xi - \zeta$, which is ambiguous. Possibly there exists a range of non-trivial conditions for which this is positive so that a dynamic Laffer effect exists. Agell and Persson (2001) show that under the conditions of Ireland (1994) a dynamic Laffer effect is more likely to occur when the initial lump-sum transfer-to-output ratio $T(0)/Y(0)$ is relatively

Table 4.1: Effects of Fiscal Policy Reforms on the Long-Run Government Budget Balance

effects when labor supply is fixed											
	ξ_i	ζ_i		$\nu_i+\pi_i$ $B(0)>0$			$\nu_i+\pi_i$ $B(0)=0$			$\nu_i+\pi_i$ $B(0)<0$	
			$\sigma<1$	$\sigma=1$	$\sigma>1$	$\sigma<1$	$\sigma=1$	$\sigma>1$	$\sigma<1$	$\sigma=1$	$\sigma>1$
$d\ \tau_A<0$	-	-	+	0	-	0	0	0	-	0	+
$d\ \tau_L<0$	-	0	0	0	0	0	0	0	0	0	0
$d\ \tau_C<0$	-	0	0	0	0	0	0	0	0	0	0
$d\ \omega_G>0$	-	0	0	0	0	0	0	0	0	0	0
effects of changes in labor supply											
	ξ_i^l	ζ_i^l		$\nu_i^l+\pi_i^l$ $B(0)>0$			$\nu_i^l+\pi_i^l$ $B(0)=0$			$\nu_i^l+\pi_i^l$ $B(0)<0$	
			$\sigma<1$	$\sigma=1$	$\sigma>1$	$\sigma<1$	$\sigma=1$	$\sigma>1$	$\sigma<1$	$\sigma=1$	$\sigma>1$
$d\ \tau_A<0$	+/-	-	+	0	-	0	0	0	-	0	+
$d\ \tau_L<0$	+/-	-	+	0	-	0	0	0	-	0	+
$d\ \tau_C<0$	+/-	-	+	0	-	0	0	0	-	0	+
$d\ \omega_G>0$	+/-	-	+	0	-	0	0	0	-	0	+

Notes: ξ denotes the direct budget effect, ζ is part of the growth effect corresponding to the case where the path of lump-sum transfers is predetermined, υ denotes the discount rate effect, and π denotes the growth rate effect. The parameter σ denotes the inverse of the intertemporal elasticity of substitution and $B(0)$ denotes the initial stock of debt, where $B(0)>0$ denotes the situation where initial debt is positive and $B(0)<0$ denotes the situation where the government acts as a creditor to the private sector.

high. From equations (4.22) and (4.25) it is straightforward to see that this means that, in absolute sense, ζ is relatively large compared to ξ so that $\xi-\zeta$ is more likely to be positive.

The analysis of Bruce and Turnovsky (1999) is replicated by setting $B(0)>0$ and noting that the path of lump-sum transfers is not assumed to be predetermined.[14] Also, in their analysis labor supply is exogenous so that their overall effect is given by the sign of $\xi+\nu+\pi$. A dynamic Laffer effect is now only possible for $\sigma<1$; see Table 4.1. Hence, not only the assumption on the path of government expenditures but also the assumption on the initial stock of public debt is needed to explain the different results of Ireland (1994) and Bruce and Turnovsky (1999).

Agell and Persson (2001) show that a dynamic Laffer effect does not exist at all for any σ. Their analysis can be replicated by noting that the path of lump-sum transfers is not assumed to be predetermined and that in addition to the decrease in the tax rate on capital income the government expenditures-to-output ratio is increased. Again labor supply is exogenous so that their overall effect is given by

[14] Although the analysis of Bruce and Turnovsky (1999) differs from ours, the mechanism is basically the same.

the sign of 2ξ, one for $d\tau_A < 0$ and one for $d\omega_G > 0$, which is always negative for any σ.

Although Table 4.1 can be used to identify the necessary conditions for a dynamic Laffer effect to exist, numerical analyses are needed to see when a dynamic Laffer effect actually occurs. This is done in the next section.

4.4. Numerical Results

We perform numerical analyses to see whether there are fiscal policy reforms that lead to an improvement in the long-run government budget balance. To this end, we calibrate the model for several European countries to see whether our model is able to replicate the main fiscal stylized facts.[15] When defining the initial balanced growth path of the economies, we use parameters and variables representative of these countries over the period 1995–2006, and the calibration is done on an annual basis.[16]

4.4.1. Calibration and Fiscal Stylized Facts

Although in practice fiscal systems are complex, consisting of a variety of statutory taxes and corresponding tax bases, we can use the implicit tax rates published by the European Commission (2008) to pin down our initial tax rates. These implicit tax rates are fairly constant over time.[17] For the public expenditures-to-output ratio and debt-to-output ratio, we use data on final government consumption and general government consolidated gross debt as a percentage of Gross Domestic Output (GDP) from the AMECO database published by the European Commission (2007). The production elasticities of capital and labor are based on the labor share of income, also taken from the AMECO database. Moreover, we set $b = \beta$ so that we abstract

[15] See Table 4.2 for a list of the countries we consider.

[16] All data used for the calibration can be found in Table 1 of the Web Appendix to the chapter; see Van Oudheusden (2012).

[17] The method for calculating the implicit tax rates is based on Mendoza et al. (1994). We use the implicit tax rate related to the taxation of income and profits of firms for the implicit tax rate on capital income, and we neglect the taxation of capital stocks and the taxation of capital transfers.

from the externalities associated with the use of labor in production. Hours per year worked are taken from the Total Economy Database provided by (The Conference Board, 2009). These data are summarized in Table 4.2 for several countries.

Table 4.2: Fiscal and Structural Parameters

	τ_A	τ_L	τ_C	ω_G	B/Y	$1-\alpha$	Hours
EA (15)	0.2520	0.3905	0.1941	0.2013	0.7038	0.6523	1700
France	0.2829	0.4173	0.2097	0.2348	0.5984	0.6648	1597
Germany	0.1979	0.3998	0.1844	0.1912	0.6513	0.6514	1473
Italy	0.2223	0.4275	0.1728	0.1898	1.1108	0.6245	1613
Spain	0.3551	0.2952	0.1543	0.1758	0.5536	0.6248	1793
United Kingdom	0.1991	0.2494	0.1953	0.1948	0.4345	0.7246	1643

Notes: The EA (15) represents 15 members of the euro area. The countries are Austria, Belgium, Cyprus, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, Netherlands, Portugal, Slovenia, and Spain. We do not assume these countries to actually represent one economy but rather think that the calibration of the benchmark economy falls within the plausible range of economies for these countries.

For the structural parameters of the model, we follow the literature when data are unavailable. The intertemporal elasticity of substitution is set to a half so that $\sigma = 2$, somewhere half way the range of values found by Attanasio and Weber (1993). They find that the intertemporal elasticity of substitution ranges from 0.3 (when using aggregate data drawn from national accounts) to 0.8 (when using cohort data drawn from a household survey) so that our choice can be justified empirically. Similar values are used by Turnovsky (2000a), Mendoza and Tesar (2005), and Itaya (2008). The depreciation rate is obtained by averaging the values used by Mendoza and Tesar (2005) and Itaya (2008), leading to $\delta = 0.08$. We set ϕ to a half and follow Turnovsky (2000a) by setting θ/ϕ to 1/3. The initial physical capital stock is normalized to one.

The utility weight of leisure η and the natural rate of time preference ρ are varied to get an exact match of both the ratio of labor supply to total time and the growth rate of the economy with the data.[18] We compare the resulting values of η and ρ with those used in the literature. The model should also be able to replicate fiscal

[18]The ratio of labor supply to total time is calculated by dividing the total hours work per year by 7300. The resulting ratios are close to the ones aimed for in the literature; see Mendoza and Tesar (2005, p. 190). Data on the growth rates are taken from the AMECO database.

stylized facts of these countries, which are the output shares of consumption, lump-sum transfers, and tax revenues for the consumption tax, labor income tax, and capital income tax, respectively.[19] Table 4.3 gives a comparison of these stylized facts and the outcomes of the calibration of our model.

Table 4.3: Comparing Stylized Facts

	EA (15)		France		Germany		Italy		Spain		United Kingdom	
	Data	Model	Data	Model	Data	Model	Data	Model	Data	Model	Data	Model
$\tilde{L}$	0.2329	0.2329	0.2188	0.2188	0.2017	0.2017	0.2010	0.2010	0.2382	0.2382	0.2251	0.2251
γ	0.0121	0.0121	0.0127	0.0127	0.0195	0.0195	0.0068	0.0068	0.0047	0.0047	0.0176	0.0176
Output shares:												
C	0.5736	0.5604	0.5621	0.5655	0.5867	0.5832	0.5896	0.5738	0.5886	0.6166	0.5621	0.6355
T	0.1661	0.1776	0.1763	0.1904	0.1882	0.2067	0.1669	0.1689	0.1223	0.1439	0.1327	0.1293
revenues: τ_C	0.1088	0.1088	0.1167	0.1186	0.1028	0.1223	0.1034	0.0991	0.0954	0.0951	0.1187	0.1230
revenues: τ_L	0.2129	0.2547	0.2307	0.2774	0.2367	0.2604	0.1999	0.2670	0.1619	0.1844	0.1327	0.1807
revenues: τ_A	0.0281	0.0355	0.0249	0.0482	0.0238	0.0353	0.0316	0.0350	0.0343	0.0636	0.0342	0.0314
Implied:												
η/ϕ		1.9569		2.0218		2.1933		2.1120		1.9784		2.4685
ρ		0.0205		0.0233		0.0179		0.0337		0.0393		0.0135

Notes: For all economies, the depreciation rate δ is set to 0.08, the inverse of the intertemporal elasticity of substitution is set to 2, and the utility weight of consumption ϕ is set to 0.5.

The ratio of labor supply to total time that follows from the model exactly corresponds with its real-word counterpart by adjusting η. The corresponding relative weight of leisure to consumption η/ϕ is given in Table 4.3 and is close to 2 for almost all economies considered. This ratio is close to the one used by Novales and Ruiz (2002), Mendoza and Tesar (2005), and Leeper and Yang (2008), which is 2 to 3. The parameter ρ is adjusted to match the growth rate of the economy with the data. Most of the resulting values lie between 0.02 and 0.04, the range of values used in the literature (e.g., Agell and Persson, 2001; Mankiw and Weinzierl, 2006; Leeper and Yang, 2008). The natural rate of time preference seems too low for Germany and the United Kingdom, which have a relatively high growth rate compared to the other economies. This finding may be the result of assuming the depreciation rate and intertemporal elasticity of substitution to be the same for all economies, which may actually differ for Germany and the United Kingdom.

Our model performs surprisingly well in replicating the private consumption-to-output ratio and the lump-sum transfer-to-output ratio. However, it is not possible

[19]Data on the private consumption-to-output ratio and the lump sum transfer-to-output ratio are taken from the AMECO database, where we use social transfers defined as social transfers other than in kind, mainly consisting of social benefits in the form of cash. Data on tax revenues are taken from the European Commission (2008).

to get exact matches for these ratios because our model considers a closed economy so that we have no counterpart for net imports. Moreover, we do not take into account all expenditures and revenues of the government such as capital expenditures and taxes on capital stocks and transfers. The average deviation from the data is slightly more than 1.5 percentage points, which we believe is fair given the simplicity of our model. In matching the output share of tax revenues, the model also performs well for the tax rate on consumption. The output shares for labor tax revenues are higher than those observed in the data. However, this particular deviation is not specific to our model but seems to be present in other calibrated dynamic general equilibrium models as well; see Trabandt and Uhlig (2011). Deviations for capital income tax revenues as a share of output are modest.

Table 4.4: Comparing Stylized Facts: Robustness Checks

		European Area (15)					
θ	0.1667	0.0000*	0.1667	0.1667	0.1667	0.1667	0.1667
η/ϕ	1.9569	1.9569	2.0000*	1.9597	1.5408	2.0518	1.9569
ρ	0.0205	0.0225	0.0205	0.0200*	0.0737	0.0111	0.0286
$1-\alpha$	0.6523	0.6523	0.6523	0.6523	0.5452*	0.6744*	0.6523
σ	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000	1.0000*
Data	Model						
$\tilde{L}$	0.2329	0.2329	0.2329	0.2293	0.2329	0.2329	0.2329	0.2329
γ	0.0121	0.0121	0.0121	0.0115	0.0124	0.0121	0.0121	0.0121
Output shares:								
C	0.5736	0.5604	0.5604	0.5596	0.5596	0.5949	0.5526	0.5604
T	0.1661	0.1776	0.1776	0.1771	0.1776	0.1395	0.1840	0.1776
revenues: τ_C	0.1088	0.1088	0.1088	0.1086	0.1086	0.1155	0.1073	0.1088
revenues: τ_L	0.2129	0.2547	0.2547	0.2547	0.2547	0.2129	0.2634	0.2547
revenues: τ_A	0.0281	0.0355	0.0355	0.0349	0.0355	0.0700	0.0281	0.0355

Notes: The second column gives the stylized facts as observed in the data, and the third column gives the calibration as described in Table 4.3. In the remaining columns, we vary one parameter, indicated with an asterisk, at the time.

Table 4.4 show various alternative calibrations for the euro area to check the robustness of the results. The parameters that are varied are indicated with an asterisk. First, we set θ to zero so that government spending is modeled as waste. Since this increases the effective intertemporal elasticity of substitution, ρ has to increase for the growth rate to match the data but its value is still in the range used in the literature. Compared to the benchmark scenario, leisure is valued more than consumption when η/ϕ is set to 2. As a result, households supply less labor, leading

to a lower growth rate. However, deviations are very small. Making households more patient by setting ρ to 0.0200 leads to a slightly higher growth rate. The income share of labor, $1-\alpha$, can be adjusted for the model to replicate the output shares of the tax rates on labor and capital income. In the case of the tax rate on labor income, this adjustment seems implausible since it implies that the labor income share is almost as low as fifty percent. Finally, setting the intertemporal elasticity of substitution to one does not change much compared to the benchmark scenario.

It can be argued that any of the choices for the labor income share we made imply too high social returns to capital to be justified on empirical grounds. However, the mechanisms behind the dynamic Laffer effect discussed in Section 4.3.2 extend directly to models where endogenous growth is not the result of externalities but of intentional research and development by firms.[20] We have chosen for this analytical framework in particular since it provides the simplest model possible to explore these mechanisms while still being able to replicate the basic stylized facts observed in the data. Although we recognize that the calibration of more elaborate endogenous growth models deserves more attention, this is beyond the scope of the chapter, and we leave this to future research.

For all values of the parameters of the model we considered, equations (4.18a) and equation (4.18b) are both satisfied, which means that an equilibrium exists and that the economy is always in its equilibrium. Thus, we do not have to worry about the possible indeterminacy of the model. For the remaining numerical analyses, we use the calibration of the EA (15) economy unless indicated otherwise.

4.4.2. Basic Fiscal Policy Reforms

Given our choice of parameters, we analyze whether the fiscal policy reforms lead to a dynamic Laffer effect. Instead of restricting the analysis to marginal changes in the tax rates on the long-run government budget balance, we analyze a wide range of discrete changes in the tax rates. More specifically, we analyze a series of lower tax rates whereby the difference between the initial tax rate and the tax rate after the fiscal policy reform is repeatedly increased up to the point where the difference is 15

[20] For an example of these models see Barro and Sala-i-Martin (1999) and Acemoglu (2009).

percentage points. We calculate the balanced growth path corresponding to the new tax rate for every change and check both the existence (4.18a) and stability (4.18b) conditions. The same procedure is followed for the public expenditures-to-output ratio, which is repeatedly increased up to the point where the ratio is 15 percentage points higher than the initial ratio. In all cases, we follow the main assumption in the literature and assume that the path of lump-sum transfers is predetermined.

The solid lines in panels (a)–(d) of Figure 4.2 represent the overall effect of the fiscal policy reforms on the long-run government budget balance.[21] The magnitude of the overall effect is given on the vertical axis to the right. All fiscal policy reforms result in an equilibrium that is unique. Moreover, all equilibria are determinate, so there are no transitional dynamics, and the economy jumps right to the new equilibrium. Figure 4.2 shows that an improvement in the long-run government budget balance is always obtained for a lower tax rate on capital income. A lower tax rate on labor income or a higher public expenditures-to-output ratio may only lead to a dynamic Laffer effect for very substantial changes. Lowering the tax rate on consumption never leads to a dynamic Laffer effect.

One possible explanation for the contrast in these outcomes is differences in the size of the distorting effect of the fiscal instruments. The new growth rates corresponding to a fiscal policy reform of a 15 percentage points change in a fiscal instrument are 1.64 percent for the tax rate on capital income, 2.04 percent for the tax rate on labor income, 1.56 percent for the tax rate on consumption, and 1.80 percent for the public expenditures-to-output ratio. That is, based on the size of the distorting effects, it should be more likely to obtain a dynamic Laffer effect for an increase in public expenditures than for a decrease in the tax rate on capital income. Since we do not observe this, we need a different explanation.

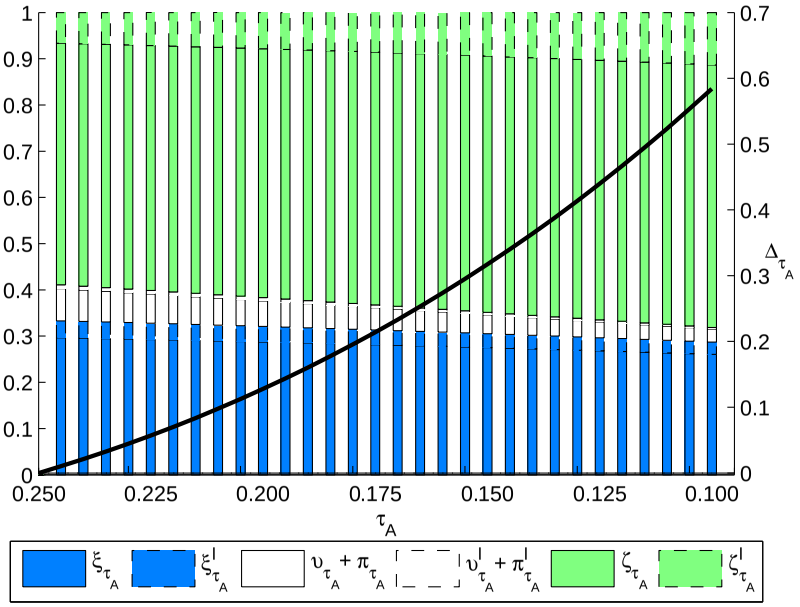
Another explanation for the observed differences in Figure 4.2 is differences in the size of the initial tax base of the fiscal instruments. The sizes of the initial tax bases are around 14, 65, and 55 percent of GDP for the tax rate on capital income, labor income, and consumption, respectively.[22] For the public expenditures-to-output

[21]The results are for the EA (15) economy. Result for the other economies can be found in the Web Appendix to the chapter.

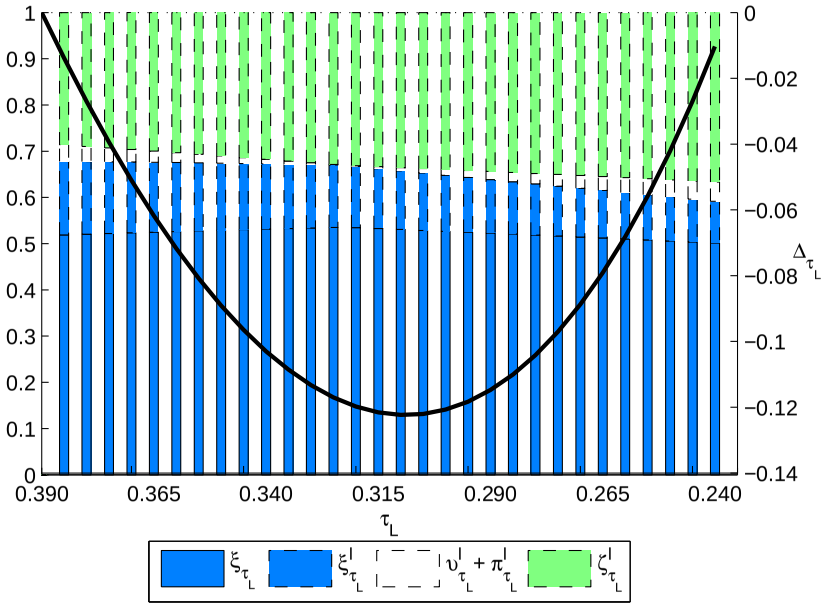
[22]We divide tax revenues as a percentage of GDP by the corresponding tax rate to obtain the

Figure 4.2: Effects of Fiscal Policy Reforms for τ_A, τ_L, τ_C, and ω_G

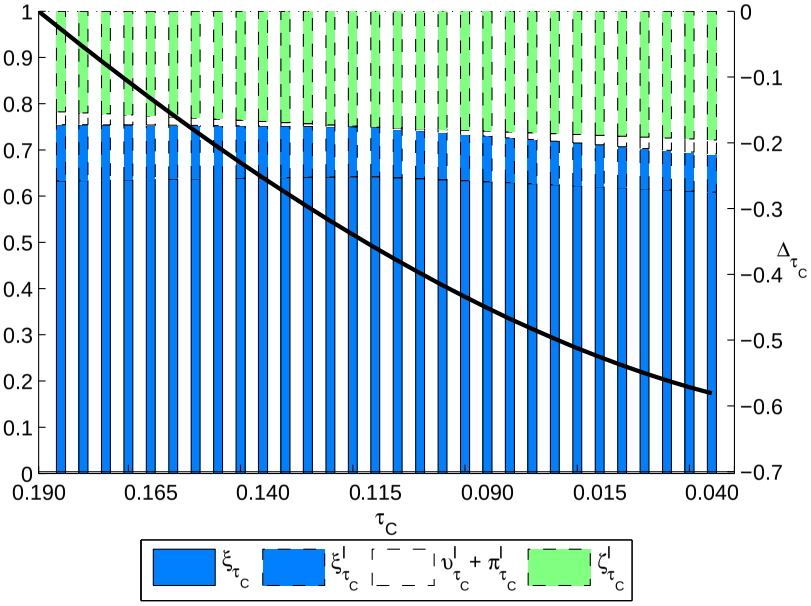
(a) Capital Income Tax



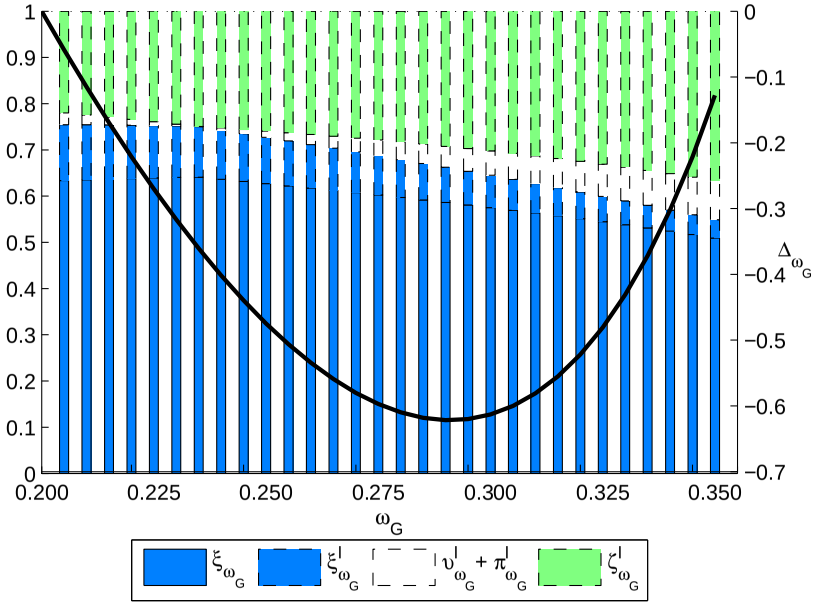
(b) Labor Income Tax



(c) Consumption Tax



(d) Government Expenditures-to-Output Ratio



ratio, the size of the initial 'tax base' is 100 percent of GDP since government expenditures are linked to the size of the economy; see (4.9). Hence, the relatively small initial tax base of the tax rate on capital income compared to that of the other fiscal instruments is a better explanation for why it is more likely to obtain a dynamic Laffer effect for this fiscal instrument.

However, a comparison of the size of both the distorting effect and initial tax base only gives an indication whether a dynamic Laffer effect can be obtained. It does not gives us insight in the exact conditions under which such an effect is obtained. Therefore, we look at the relative contributions of the basic effects to the change in the long-run government budget balance. These relative contributions are given by the stacked bars in Figure 4.2, where we make a distinction between the direct budget effect $\xi + \xi^l$ (dark gray bars), the combined discount rate effect and growth rate effect $\pi + \pi^l + \nu + \nu^l$ (white bars), and the growth rate effect corresponding to lump-sum transfers $\zeta + \zeta^l$ (light gray bars).[23]

This last effect is included to analyze the implications of the assumption that lump-sum transfers are predetermined for obtaining a dynamic Laffer effect. Recall from Section 4.3.2.2 that the growth rate effect corresponding to lump-sum transfers is negative and is implicitly captured by the combined discount rate effect and growth rate effect. Moreover, under the assumption that lump-sum transfers are predetermined, the growth rate effect corresponding to lump-sum transfers has to be removed from the analysis. The removal of this effect leads to an improvement in the long-run government budget balance, and the relative magnitude of this effect is given by $\zeta + \zeta^l$. The magnitudes of the relative contributions are given on the left vertical axis and sum up to one. The stacked bars that are dashed represent the relative contribution of the basic effects caused by changes in labor supply.

Panels (a)–(d) of Figure 4.2 show that the relative contribution of the combined discount rate effect and growth rate effect is negligible compared to the other basic effects. The total contribution of the direct budget effect is always negative although

initial tax base as a percentage of GDP; see Table 4.3.

[23]Note that the above described effects are not the marginal effects as discussed in Section 4.3.2, but the effects are only related since we analyze discrete changes here. Notes on the specific method can be found in the Web Appendix to the chapter.

the part that is caused by changes in labor supply is positive.[24] The total contribution of the growth rate effect corresponding to lump-sum transfers is always positive since this represents the removal of a negative effect. In the case of the tax rate on capital income, panel (a) of Figure 4.2, it can be seen that the relative contribution of the direct budget effect is always smaller than the relative contribution of the growth rate effect corresponding to lump-sum transfers. The opposite can be seen in the case of the tax rate on labor income, the tax rate on consumption, and the public expenditures-to-output ratio; see panels (b)–(d) of Figure 4.2. Hence, the relative magnitude of the growth effect corresponding to lump-sum transfers and the direct budget explains why we do obtain a dynamic Laffer effect for a lower tax rate on capital income and do not obtain it for the other fiscal instruments.

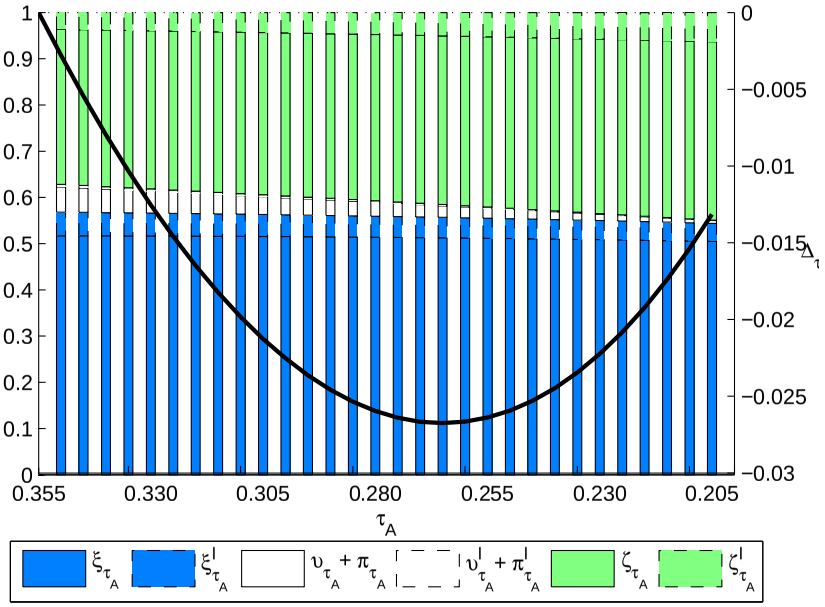
We now calculate the quantitative effects of the different assumptions we make, such as taking into account the initial stock of public debt and allowing for changes in labor supply. The effects of these assumptions can be seen in Figure 4.3, where we look at the effects of lower tax rates on capital income for Spain. Panel (a) gives the scenario where both the initial stock of public debt and changes in labor supply are taken into account. In this case, no dynamic Laffer effect is obtained, which means it is not always the case that a lower tax rate on capital leads to an improvement in the long-run budget balance of the government. If the initial stock of public debt is neglected, as in panel (b), a dynamic Laffer effect is always obtained. Hence, neglecting the stock of initial debt leads to an overestimation of the dynamic Laffer effect. If instead changes in labor supply are not taken into account, it becomes harder to obtain a dynamic Laffer effect; compare panel (a) and (c), and panel (b) and (d). Assumptions on the initial stock of public debt and labor supply thus affect the size of the tax rate reduction needed to obtain a dynamic Laffer effect, where the size is decreasing and increasing when neglecting the initial stock of public debt and changes in labor supply, respectively.

All of the obtained dynamic Laffer effects so far are the result of the assumption that the path of lump-sum transfers is predetermined. However, this assumption

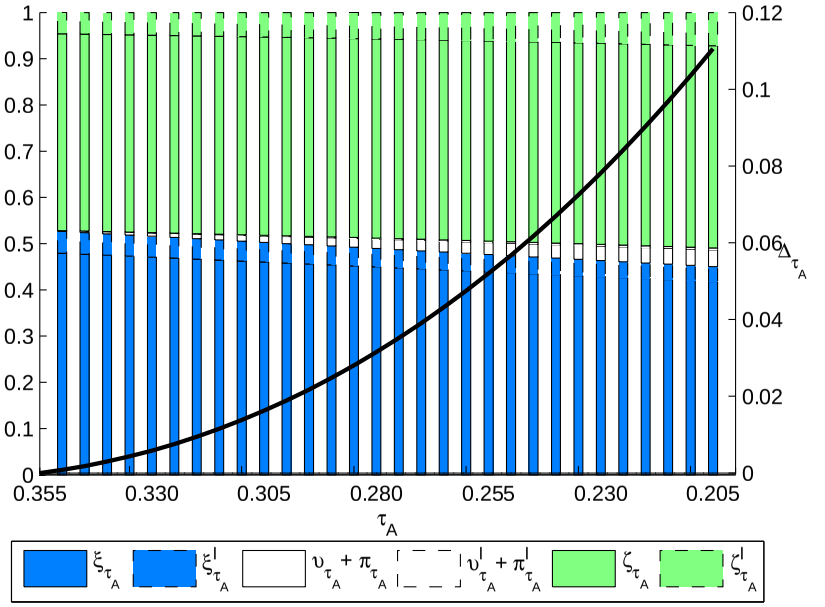
[24]Note that the direct budget effect of a change in a fiscal instrument does not correspond one-to-one with the initial size of the corresponding tax base since the tax base of other fiscal instruments also matters; see (4.22).

Figure 4.3: Different Scenarios for the Capital Income Tax Rate Reform in Spain

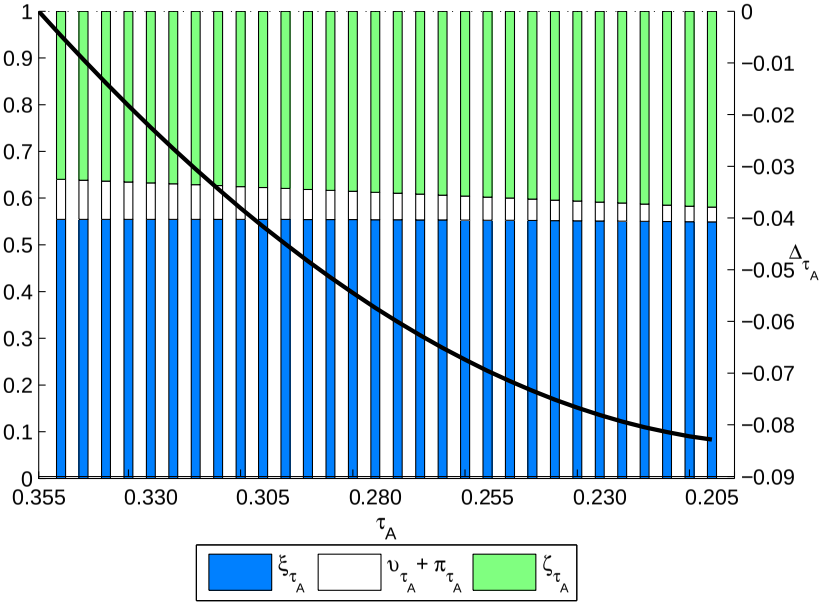
(a) Changes in Labor; Debt



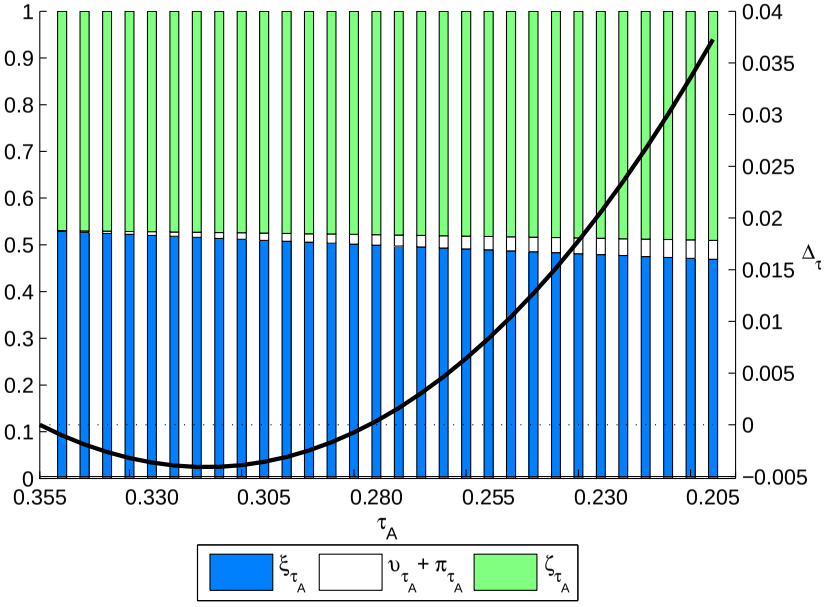
(b) Changes in Labor; No Debt



(c) No Changes in Labor; Debt



(d) No Changes in Labor; No Debt



implies that the transfers-to-output ratio goes to zero over time after the fiscal policy reforms we consider, which seems a rather strong assumption. By looking at combinations of fiscal policy reforms, we analyze whether an improvement in the long-run government budget is also possible when lump-sum transfers always grow at the same rate as the economy so that the transfers-to-output ratio remains constant over time.

4.4.3. Composite Fiscal Policy Reforms

We define a composite fiscal policy reform as a combination of changes in the tax rates on capital income, labor income, and consumption, while letting transfers grow at the same rate as the economy. More specifically, we analyze composite fiscal policy reforms, consisting of a range of lower tax rates on capital income or labor income in combination with a range of higher tax rates on consumption, to see under which conditions an improvement in the long-run government budget balance occurs. Hereby, we start at the initial tax rates of the benchmark economy and impose the additional condition that the new combinations of tax rates should lead to an improvement in lifetime welfare. We define the change in lifetime welfare as the percentage change in private goods consumption before the fiscal policy reform necessary to obtain the same present discounted value of utility as after the fiscal policy reform. Moreover, we make a distinction between immediate and long-run welfare effects.[25] The area in panel (a) of Figure 4.4 represents the combinations of capital income tax rates and consumption tax rates that lead to an improvement in both the long-run government budget balance and lifetime welfare. The area in panel (b) represents the combinations of the labor income tax rates and the consumption tax rates for which these conditions hold. From now on, these combinations are called "feasible combinations."[26]

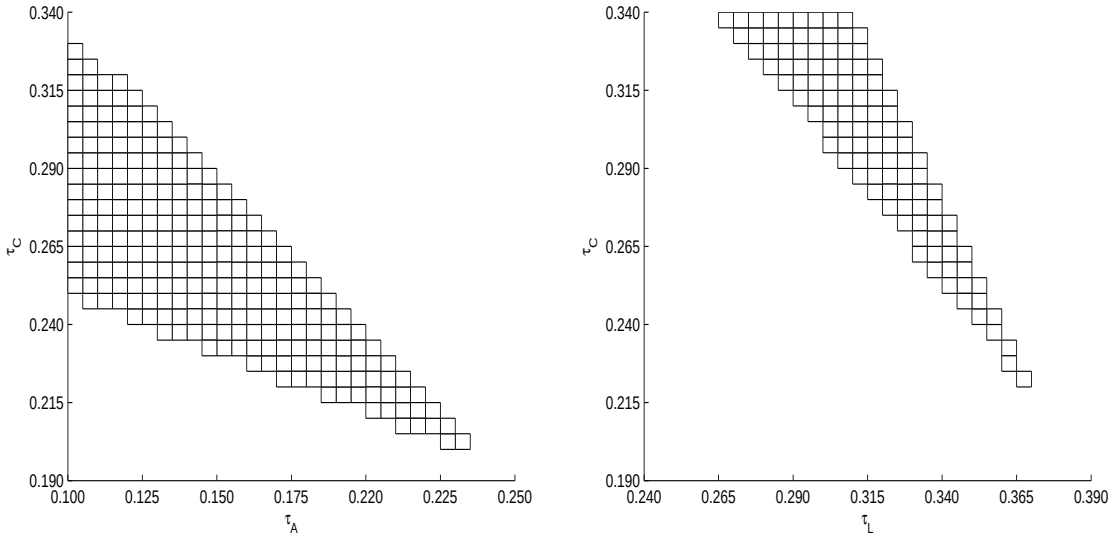
For all feasible combinations in panel (a) of Figure 4.4, labor supply is decreasing resulting in a lower after-tax return on capital. However, the lower tax rates on

[25]Again, notes on the method used are available in the Web Appendix to the chapter see Van Oudheusden (2012).

[26]For all combinations of the tax rates, the conditions for existence (4.18a) and stability (4.18b) are examined. All composite fiscal policy reforms result in an equilibrium that is unique. Moreover, all equilibria are determinate, so the economy jumps right to the new equilibrium.

Figure 4.4: Composite Fiscal Policy Reforms

(a) Capital Income and Consumption Tax (b) Labor Income and Consumption Tax



Notes: The areas represent combinations of after-reform tax rates for which there is an improvement in both the long-run government budget balance and overall welfare. Initial tax rates are $\tau_A = 0.2520$, $\tau_L = 0.3905$, and $\tau_C = 0.1941$ for the tax rate on capital income, labor income, and consumption, respectively.

capital income lead to a higher after-tax return on capital. The latter effect dominates the former so that the growth rate of the economy is increasing for all feasible combinations. This finding is in contrast with the fiscal policy reforms analyzed in Section 4.4.2, where both the supply of labor and the growth rate of the economy always increase. For all feasible combinations the lifetime welfare effect is positive by definition. However, the immediate welfare effect is always negative, and this raises the question whether the reforms will be implemented in the first place. All feasible combinations in panel (b) of Figure 4.4 lead to an increase in labor supply and thus to an increase in the growth rate of the economy since the growth rate in this case is only affected by changes in labor supply. In contrast to panel (a) of Figure 4.4, both the immediate and long-run welfare effects are positive. This means that these fiscal policy reforms may be more likely to be implemented. In both cases, feasible combinations are not found for marginal changes in tax rates but for discrete changes only.

4.5. Conclusions

Using a one-sector model of endogenous growth with endogenous labor supply and allowing for different structures of government spending and public debt, we analytically explain and reconcile the seemingly different results found in the literature on the dynamic Laffer effect. Moreover, we numerically show that lowering the tax rate on capital income is the best candidate for obtaining a dynamic Laffer effect for the euro area. However, this result hinges on the assumption that the path of lump-sum transfers is predetermined. When this assumption is relaxed, an improvement in the long-run government budget balance is still possible if lower tax rates on factor income, here capital income and labor income, are financed by a higher tax rate on consumption. The combinations of tax rates for which this improvement is possible differ in their implications for the changes in both labor supply and immediate welfare though.

A direction for future research is the inclusion of political economy elements that allow a more thorough analysis of issues concerning the political feasibility of the fiscal policy reforms discussed in our analysis. A first step would be an adjustment of the framework such that an explicit distinction between current and future generations is possible. Another avenue for future research is an extensive analysis of the effect of fiscal policy reforms on the debt-to-output ratio over time. It then can be examined whether after a fiscal policy reform the debt-to-output ratio exceeds legal thresholds imposed by the Growth and Stability Pact, thereby providing additional criteria for the implementation of the reforms. More importantly, potential large debt-to-output ratios resulting from a fiscal policy reform are likely to give rise to a risk-premium on bonds. Together with uncertainty, the risk-premium would make the return on bonds endogenous and may alter the current analysis. Finally, dynamic Laffer effects may be studied in a more elaborate framework where growth is the result of intentional innovation by firms rather than of social returns to capital. In this case, the equilibrium should be analytically tractable to facilitate a thorough calibration of the model.

Appendix 4.A

4.A.1 Existence of the Equilibrium

Both (4.17a) and (4.17b) are defined for $L \in (0, 1]$. Over this interval it holds that

$$\begin{aligned}
\gamma_P(L) &= \frac{(1-\tau_A)(aL^\beta - \delta) - \rho}{1-(1-\sigma)(\phi+\theta)}, \\
\frac{\partial \gamma_P(L)}{\partial L} &= \frac{(1-\tau_A)a\beta L^{\beta-1}}{1-(1-\sigma)(\phi+\theta)} > 0, \\
\frac{\partial^2 \gamma_P(L)}{\partial L^2} &= -\frac{(1-\tau_A)a\beta(1-\beta)L^{\beta-2}}{1-(1-\sigma)(\phi+\theta)} < 0, \\
\gamma_Q(L) &= L^\beta \left[1 - \omega_G - \frac{1-\tau_L}{1+\tau_C}\frac{b}{\beta}\frac{b\phi}{\eta}\frac{1-L}{L}\right] - \delta, \\
\frac{\partial \gamma_Q(L)}{\partial L} &= L^\beta \left[\frac{(1-\omega_G)\beta}{L} + \frac{1-\tau_L}{1+\tau_C}\frac{b\phi}{\eta}\frac{1-L}{L}\left(\frac{1-\beta}{L} + \frac{1}{1-L}\right)\right] > 0, \\
\frac{\partial^2 \gamma_Q(L)}{\partial L^2} &= L^\beta \left[\frac{(1-\omega_G)\beta^2}{L^2} + \frac{1-\tau_L}{1+\tau_C}\frac{b\phi}{\eta}\frac{1-L}{L}\left(\frac{\beta(1-\beta)}{L^2} + \frac{2\beta}{L(1-L)}\right)\right] \\
&\quad - L^\beta \left[\frac{(1-\omega_G)\beta}{L^2} + \frac{1-\tau_L}{1+\tau_C}\frac{b\phi}{\eta}\frac{1-L}{L}\left(\frac{2(1-\beta)}{L^2} + \frac{2}{L(1-L)}\right)\right] < 0,
\end{aligned}$$

where we used that $0 < \beta < 1$. Moreover

$$\begin{aligned}
\lim_{L\to 0} \gamma_P(L) &= \frac{-\delta(1-\tau_A) - \rho}{1-(1-\sigma)(\phi+\theta)}, & \lim_{L\to 0} \gamma_Q(L) &= -\infty, \\
\gamma_P(1) &= \frac{(a-\delta)(1-\tau_A) - \rho}{1-(1-\sigma)(\phi+\theta)}, & \gamma_Q(1) &= 1 - \omega_G - \delta.
\end{aligned}$$

Now, a unique equilibrium exists if $\gamma_P(1) < \gamma_Q(1)$. This is the case if

$$\sigma > 1 - \frac{1 - \omega_G - (a-\delta)(1-\tau_A) + \rho}{(1-\omega_G)(\phi+\theta)}.$$

4.A.2 Stability of the Equilibrium

We define $\Omega_P(L) \equiv \partial\gamma_P(L)/\partial L$ and $\Omega_Q(L) \equiv \partial\gamma_Q(L)/\partial L$. The sign of the derivative of the rate of growth of labor supply (4.14) with respect to labor, valued at $\tilde{L}$, is given by

$$sgn\left\{\left.\frac{d\dot{L}/L}{dL}\right|_{L=\tilde{L}}\right\} = sgn\left\{\frac{1-(1-\sigma)(\phi+\theta)}{\Theta^D(\tilde{L})}\left[\Omega_P(\tilde{L}) - \Omega_Q(\tilde{L})\right]\right\}. \tag{A.1}$$

If (A.1) is positive, then small deviations in labor supply lead to a permanent deviation from $\tilde{L}$ so that the equilibrium is locally unstable and said to be locally determinate. If (A.1) is negative, then small deviations of the supply of labor will force labor supply back to $\tilde{L}$ so that the equilibrium is locally stable and said to be locally indeterminate. Since $\Omega_Q(\tilde{L}) > \Omega_P(\tilde{L})$ when a unique equilibrium exists, and $1-(1-\sigma)(\phi+\theta) > 0$ by the concavity of the felicity function, the equilibrium is locally unstable if $\Theta^D(\tilde{L}) < 0$.

4.A.3 Comparative Static Effects

The comparative static effects of the various tax rates are as follows:

$$\begin{aligned}
\frac{d\tilde{L}}{d\tau_A} &= \left[\Omega_P(\tilde{L}) - \Omega_Q(\tilde{L})\right]^{-1} \frac{a\tilde{L}^\beta - \delta}{1-(1-\sigma)(\phi+\theta)} < 0, \\
\frac{d\tilde{L}}{d\tau_L} &= \left[\Omega_P(\tilde{L}) - \Omega_Q(\tilde{L})\right]^{-1} \frac{b\phi}{\eta}\tilde{L}^\beta \frac{1-\tilde{L}}{\tilde{L}} \frac{1}{1+\tau_C} < 0, \\
\frac{d\tilde{L}}{d\tau_C} &= \left[\Omega_P(\tilde{L}) - \Omega_Q(\tilde{L})\right]^{-1} \frac{b\phi}{\eta}\tilde{L}^\beta \frac{1-\tilde{L}}{\tilde{L}} \frac{1}{1+\tau_C} \frac{1-\tau_L}{1+\tau_C} < 0, \\
\frac{d\tilde{L}}{d\omega_G} &= \left[\Omega_P(\tilde{L}) - \Omega_Q(\tilde{L})\right]^{-1} (-\tilde{L}^\beta) > 0,
\end{aligned}$$

where $\Omega_P(\tilde{L}) > \Omega_Q(\tilde{L})$ in the equilibrium that is determinate. In an indeterminate equilibrium it holds that $\Omega_P(\tilde{L}) < \Omega_Q(\tilde{L})$ so that the effects are reversed.

$$\begin{aligned}
\frac{d\gamma(\tilde{L})}{d\tau_A} &= \Omega_P(\tilde{L})\frac{d\tilde{L}}{d\tau_A} - \frac{a\tilde{L}^\beta - \delta}{1-(1-\sigma)(\phi+\theta)} < 0, \\
\frac{d\gamma(\tilde{L})}{d\tau_L} &= \Omega_P(\tilde{L})\frac{d\tilde{L}}{d\tau_L} < 0, \\
\frac{d\gamma(\tilde{L})}{d\tau_C} &= \Omega_P(\tilde{L})\frac{d\tilde{L}}{d\tau_C} < 0, \\
\frac{d\gamma(\tilde{L})}{d\omega_G} &= \Omega_P(\tilde{L})\frac{d\tilde{L}}{d\omega_G} > 0.
\end{aligned}$$

5

Dynamic Scoring in a model with Creative Destruction[1]

5.1. Introduction

Governments face the challenge to set fiscal policies such that they result in sufficient revenues to deal with long-run budget challenges and promote economic growth at the same time. This challenge is especially relevant for governments currently proposing fiscal reforms to reduce their fiscal deficits and bring down their debt. Scoring exercises, which are analyses of the impact of fiscal policies on the long-run budget balance of the government and the economy, are useful tools to see whether these two goals can be satisfied simultaneously. These scoring exercises increasingly take place in dynamic general equilibrium frameworks and are referred to as dynamic scoring exercises.

Most dynamic scoring exercises use models where economic activity is solely determined by traditional factors of production such as physical capital and labor.[2] So far, less attention is being paid to the use of models where economic activity is the result of intentional investment in research and development (R&D) by firms. However, scoring exercises are especially interesting in these models since they feature monopolistic distortions and usually some form of externalities (e.g., research spillovers). Therefore, they lend themselves to studying active government involve-

[1]This chapter is based on Van Oudheusden (2011)

[2]See Ireland (1994), Agell and Persson (2001), Mankiw and Weinzierl (2006), Trabandt and Uhlig (2011), Van Oudheusden (2009), and Strulik and Trimborn (2012).

ment. More important, the question whether the government is able to deal with these distortions and externalities remains largely unanswered when either only a part of government activities is taken into account or when it is assumed that the government can raise funds at no cost to economy activity. Such an analysis requires a calibrated framework in which the government plays a prominent role. This chapter addresses these issues and performs dynamic scoring exercises in an economic model with intentional innovation by firms. We do this by examining the dynamic feedback effects of fiscal policies on the government budget in a calibrated general equilibrium framework featuring endogenous growth through creative destruction.

The production side of the closed economy takes standard "Schumpeterian" growth models (cf. Aghion and Howitt, 1998; Acemoglu, 2009) as a basis. Expenditures of the government consist of interest payments on debt, public consumption, and lump-sum transfers to households. The government finances these expenditures by issuing debt and collecting taxes on capital income, labor income, and consumption. Moreover, the government provides tax incentives with respect to research effort to affect the economy (e.g., investment tax credits and depreciation allowances for research and development expenditures). To prevent the government from raising revenues in a non-distorting way, we assume labor supply is elastic. Finally, we calibrate the model to resemble the economies of the United Kingdom and three major European continental countries, which are France, Germany, and Italy.

We use this calibrated framework to perform dynamic scoring analyses for more generous tax incentives with respect to research effort, lower tax rates on capital income, labor income and consumption, and a higher share of government expenditures in output. From these dynamic scoring analyses it follows that more generous tax incentives with respect to research effort is the least costly way, in terms of the impact on the government budget, to stimulate economic activity. This policy is almost three times as cost effective as lowering the tax rate on capital income, which is the next best policy. We never obtain a dynamic Laffer effect, which is an improvement in the long-run government budget balance, for the fiscal policies considered. This last finding can be explained by the relatively large deterioration

of the government budget balance in the short run compared to the resulting efficiency gains of these policies in the long run. Finally, when non-distorting financing options are unavailable, more generous tax incentives with respect to research effort can best be financed by cutting government expenditures and raising the tax rate on consumption.

The framework we develop in this chapter has characteristics that makes it suitable to also address other issues than dynamic scoring analyses. The model has closed form solutions in equilibrium, features tractable transitional dynamics, and comes with a graphical apparatus that provides a clear insight in the mechanisms that are at work after a change in a fiscal instrument. Moreover, the inclusion of a wide array of fiscal instruments available to the government makes it possible to include almost all government expenditures and revenues that are found in the national accounts of countries. Because of these characteristics, the framework is useful to study, for example, optimal taxation questions. Although these questions are interesting on their own, we do not address them here and leave them for future research.

Our analysis is closely related to Trabandt and Uhlig (2011) who perform dynamic scoring analyses for the United States and several European countries in a neoclassical growth model. We mainly differ from this study by looking at a framework where economic activity results from intentional innovation by firms and by analyzing a wider variety of financing schemes.[3] Other related papers in the dynamic scoring literature are Ireland (1994), Bruce and Turnovsky (1999), Agell and Persson (2001), and Van Oudheusden (2009), who look at the conditions under which a dynamic Laffer effect can be obtained. Mankiw and Weinzierl (2006) and Strulik and Trimborn (2012) perform dynamic scoring analyses in a standard neoclassical growth model and focus on the degree of self-financing of fiscal policy reforms. None of these papers considers economic activity to be the result of intentional research by firms, and all papers limit the number of financing schemes. Our paper is also related to Jones (1995), Jones and Williams (2000), Zeng and Zhang (2007), and

[3]We consider three financing schemes: i) a non-distorting financing scheme, ii) a non-distorting scheme where debt is allowed to adjust, and iii) a distorting financing scheme.

Grossmann et al. (2010), who calibrate R&D-based models of economic growth but differ substantially in their treatment of the elasticity of labor supply and coverage of fiscal instruments available to the government.

The remainder of the chapter is structured as follows. Section 5.2 sets out the analytical framework. Section 5.3 presents the analytical results. Section 5.4 discusses the numerical results. Section 5.5 concludes.

5.2. Analytical Framework

The building block of the model is a "Schumpeterian growth model" similar to those discussed by Aghion and Howitt (1998), Barro and Sala-i-Martin (1999), and Acemoglu (2009).[4] We consider a closed economy where the production side consists of a final goods sector, an intermediate goods sector, and a research sector. Other economic actors are households and the government.

5.2.1. The Final Goods Sector

The final goods sector operates under perfect competition and produces a homogeneous output good $Y(t)$ using a continuum of intermediate goods, normalized to unity, and aggregate labor:

$$Y(t) = \alpha^{-1} \left(\int_0^1 Q_i(t)^{\theta} x_i(t|Q_i(t))^{\frac{\epsilon_\beta - 1}{\epsilon_\beta}} di \right)^{\frac{\alpha \epsilon_\beta}{\epsilon_\beta - 1}} H(t)^{1-\alpha}, \tag{5.1}$$

where $0 < \alpha < 1$, $\theta > 0$, $\epsilon_\beta > 1$, $x_i(t|Q_i(t))$ is the quantity of intermediate good i at time t with quality $Q_i(t)$, θ measures how this quality affects the productivity of the intermediate good, and ϵ_β is the elasticity of substitution between the differentiated intermediate goods. Aggregate labor is given by $H(t)$ and its production elasticity is $1 - \alpha$.

We take output as the numeraire and normalize its price to unity. Profits of the final goods sector are given by $(1-\tau_X)(Y(t) - w(t)H(t)) - \int_0^1 p_i(t|Q_i(t))x_i(t|Q_i(t))di$, where

[4] More specifically, the model contains elements of but is not identical to the models described by Aghion and Howitt (1998, Chapter 3), Barro and Sala-i-Martin (1999, Chapter 7), and Acemoglu (2009, Chapter 14).

τ_X is the tax rate on capital income, w_t is the wage rate, and $p_i(t|Q_i(t))$ is the price of intermediate good i at time t with quality $Q_i(t)$.[5] Profit maximization gives demand functions for intermediate goods and aggregate labor, respectively:

$$x_i(t|Q_i(t)) = \left(\frac{p_i(t|Q_i(t))}{Q_i(t)^\theta}\right)^{-\epsilon_\beta} P(t)^{\epsilon_\beta - \frac{1}{1-\alpha}} H(t)(1-\tau_x)^{\frac{1}{1-\alpha}}, \tag{5.2}$$

$$H(t) = \left(\int_0^1 Q_i(t)^\theta x_i(t|Q_i(t))^{\frac{\epsilon_\beta - 1}{\epsilon_\beta}} di\right)^{\frac{\epsilon_\beta}{\epsilon_\beta - 1}} \left(\frac{1-\alpha}{\alpha}\right)^{\frac{1}{\alpha}} w(t)^{-\frac{1}{\alpha}}, \tag{5.3}$$

and $P(t)$ is a price index given by $P(t) \equiv \left(\int_0^1 p_i(t|Q_i(t))^{1-\epsilon_\beta} Q_i(t)^{\theta\epsilon_\beta} di\right)^{\frac{1}{1-\epsilon_\beta}}$.

5.2.2. The Intermediate Goods Sector

The intermediate good i with quality $Q_i(t)$ is produced by a representative firm that owns a potentially infinitely lived patent for the use of that good. This patent can be bought from the research sector and its value is given by

$$V_i(t|Q_i(t)) = \int_t^\infty \pi_i(t'|Q_i(t)) e^{\int_t^{t'} \left(r(t'') + z_i(t''|Q_i(t))\right) dt''} dt'.$$

This equation can be written in a more convenient way by taking the time derivative and rearranging terms:[6]

$$r(t)V_i(t|Q_i(t)) = \pi_i(t|Q_i(t)) + \dot{V}_i(t|Q_i(t)) - z_i(t|Q_i(t))V_i(t|Q_i(t)). \tag{5.4}$$

Equation (5.4) says that the per period expected income of owning a patent $r(t)V_i(t|Q_i(t))$ equals the profit in that period $\pi_i(t|Q_i(t))$, plus the change in the value of the patent $\dot{V}_i(t|Q_i(t))$, and minus the expected loss of losing the patent $z_i(t|Q_i(t))V_i(t|Q_i(t))$ by being replaced; see Section 5.2.3 for the last effect. In this equation, $r(t)$ is the market interest rate, and $z_i(t|Q_i(t))$ is the Poisson arrival rate of innovations, also called the flow rate of innovations, on intermediate good i with quality $Q_i(t)$.

Per period profits are given by $\pi_i(t|Q_i(t)) = p_i(t|Q_i(t))x_i(t|Q_i(t)) - \psi Q_i(t)^\theta x_i(t|Q_i(t))$, where the marginal costs $\psi Q_i(t)^\theta$, with $\psi > 0$, are increasing in the quality of the

[5] Hence, the intermediate goods can be seen as capital; see Acemoglu (2009).

[6] The result is the Hamilton-Jacobi-Bellman representation of the value of the patent; see Acemoglu (2009, p. 244).

intermediate good, which captures the idea that it is more expensive to produce intermediate goods of higher quality. Firms in the intermediate sector act like monopolists when maximizing their profits. Assuming firms are small and charge the unconstrained monopoly price, firms set their price as a markup over marginal costs:

$$p_i(t|Q_i(t)) = \frac{\epsilon_\beta}{\epsilon_\beta - 1}\psi Q_i(t)^\theta, \tag{5.5}$$

so that profits are given by[7]

$$\pi_i(t|Q_i(t)) = \left(\frac{\epsilon_\beta}{\epsilon_\beta - 1}\frac{\psi}{1-\tau_X}\right)^{\frac{\alpha}{\alpha-1}} Q_i(t)^\theta \left(\int_0^1 Q_i(t)^\theta di\right)^{\frac{1}{1-\epsilon_\beta}\left(\epsilon_\beta - \frac{1}{1-\alpha}\right)} \frac{H(t)}{\epsilon_\beta}(1-\tau_X). \tag{5.6}$$

5.2.3. The Research Sector

Each intermediate good sector has it own research sector where firms compete to discover the next quality improvement of that good. The quality of intermediate good i at time t is given by the following quality ladder:

$$Q_i(t) = Q_i(0)e^{\frac{S_i(t)}{v-1}},$$

where $v > 1$, $Q_i(0) > 0$, and S_i is the total number of innovations on intermediate good i between time 0 and time t. The total number of innovations depends on the flow rate of innovations; $\dot{S}_i(t) = z_i(t)$. Since $z_i(t|Q_i(t))$ is the Poisson arrival rate of innovations, quality improvements of a particular intermediate good are stochastic. For an incumbent, $z_i(t|Q_i(t))$ is the probability of being replaced by an entrant.

Firms in the research sector spend $Z_i(t|Q_i(t))$ units of the final good on research effort, where a successful innovation gives the firm a patent with value $V_i(t|Q_i(t))$. The relation between the flow rate of innovations $z_i(t|Q_i(t))$ and research effort is given by

$$z_i(t|Q_i(t)) = \eta\Phi(Q_i(t))Z_i(t|Q_i(t)),$$

[7]Equation (5.5) is obtained by substituting equation (5.2) into the expression for per period profits and maximizing with respect to $p_i(t|Q_i(t))$, where the effect of $p_i(t|Q_i(t))$ on $P(t)$ is neglected since the size of firms is small. Equation (5.6) is obtained by substituting equation (5.5) into $P(t)$, and subsequently substituting the result and equation (5.2) into the expression for per period profits.

where $\eta > 0$ is the productivity of research effort, and $\Phi(\cdot)$ with $\partial\Phi(\cdot)/\partial Q_i(t) < 0$ captures the idea that it becomes harder to obtain a successful innovation when the quality of the intermediate good is higher.

Expected profits of research are given by $z_i(t|Q_i(t))V_i(t|Q_i(t)) - (1 - s_Z)Z_i(t|Q_i(t))$, where we assume the government provides tax incentives, denoted by s_Z, to stimulate research effort. The parameter s_Z captures the generosity of the tax incentives with respect to research effort, which may capture exemptions, allowances, credits, tax deferrals and rate reliefs. Since these tax incentives can be seen as an implicit subsidy to research effort, we model them accordingly. Free entry in the research sector implies zero profits, which leads to the following conditions:

$$V_i(t|Q_i(t)) = \frac{1 - s_Z}{\eta\Phi(Q_i(t))} \quad \text{if} \quad Z_i(t|Q_i(t)) > 0,$$
$$V_i(t|Q_i(t)) < \frac{1 - s_Z}{\eta\Phi(Q_i(t))} \quad \text{if} \quad Z_i(t|Q_i(t)) = 0,$$

where the first equation is the free entry condition when research effort takes place and implies that $\dot{V}_i(t|Q_i(t)) = 0$ since $Q_i(t)$ is constant over time until there is a new innovation. This free entry condition can be rewritten as[8]

$$z_i(t|Q_i(t)) = \pi_i(t|Q_i(t))\frac{\eta\Phi(Q_i(t))}{1 - s_Z} - r(t),$$

which is affected by the quality of the intermediate good in two opposite ways. The first effect is captured by $\pi_i(t|Q_i(t))$ and says that the return on research effort increases with $Q_i(t)$ since profits depends positively on the quality of the intermediate good; see equation (5.6). The second effect is captured by $\Phi(Q_i(t))$ and says it becomes harder to obtain a successful innovation when the quality of the intermediate good is higher, which means the return on research effort decreases with $Q_i(t)$.

If the first effect dominates the second, then the return on research effort increases with quality, and research effort will focus on the intermediate goods with the highest quality. Conversely, research effort shifts to the intermediate goods with the lowest quality if the second effect dominates. In both cases, research effort depends on

[8]This result is obtained by substituting $V_i(t|Q_i(t)) = \frac{1-s_Z}{\eta\Phi(Q_i(t))}$ into (5.4), taking into account that $\dot{V}_i(t|Q_i(t)) = 0$, and rearranging terms.

the quality of the intermediate goods. Since quality improvements are stochastic, the model becomes analytically intractable. The only situation in which we can say something about the growth process is when research effort is independent of the quality of intermediate goods, which is the case when the two effects exactly offset each other.

Because we do not want to limit our attention to this particular case, we need to adjust the model in such a way that research effort is the same for all intermediate goods regardless of which effect dominates. We do this by following Aghion and Howitt (1992, 1998). Suppose now that after a successful innovation at time t, the quality of an intermediate good does not follow the quality ladder given above but instead jumps to the leading-edge quality in the whole economy at that time, which is denoted by $Q(t)$. Any innovation then leads to a discontinuous jump of the quality that is currently being used in the production of that good to this leading-edge quality. More specifically, a new firm now produces the intermediate good using the leading-edge quality and replaces the old firm that uses the old quality. Moreover, suppose now that the flow rate of innovation is given by

$$z_i(t|Q(t)) = \eta\Phi(Q(t))Z_i(t|Q(t)) = \eta Q(t)^{-\phi}Z_i(t|Q(t)),$$

where we defined $\Phi(Q(t)) \equiv Q(t)^{-\phi}$, and $\phi > 0$ indicates that the effectiveness of research effort decreases with the leading-edge quality. The free entry condition changes into

$$z_i(t|Q(t)) = \pi_i(t|Q(t))\frac{\eta Q(t)^{-\phi}}{1-s_Z} - r(t). \tag{5.7}$$

which again says that the return on research effort on intermediate good i is still affected in two opposite ways, though not by the quality of the intermediate good itself but by the leading-edge quality in the economy. Moreover, equation (5.7) implies that research effort will be the same for all intermediate goods.

We follow Aghion and Howitt (1998) and assume that the evolution of the leading-edge quality over time is proportional to the aggregate flow rate of inno-

vations:[9]

$$\frac{\dot{Q}(t)}{Q(t)} = \frac{z(t)}{v-1}, \tag{5.8}$$

with $z(t) = \int_0^1 z_i(t)di$. A graphical representation of this process of quality improvements of the intermediate goods is given in Figure 5.1.

Figure 5.1 shows that both the distribution of qualities and the leading-edge quality change over time. However, it can be shown that the distribution of relative qualities $q_i \equiv Q_i/Q$ is independent of the leading-edge quality and thus time independent: $J(q) = q^{v-1}$. This property implies that intermediate goods can be classified according to their relative qualities so that the sum of qualities used in the production of intermediate goods at time t is given by[10]

$$\int_0^1 Q_i(t)^\theta di = \frac{v-1}{v-1+\theta} Q(t)^\theta. \tag{5.9}$$

5.2.4. Households

The economy consists of a set of infinitely lived identical households, where for convenience the number of households is normalized to unity. The size of the representative household is given by $N(t)$, which evolves according to $N(t) = N(0)e^{nt}$, where $N(0) = 1$, and $n \geq 0$ is the growth rate. Each household has the same felicity function so that lifetime utility of the representative household is given by

$$\Lambda(0) \equiv \int_0^\infty N(t)u(t)e^{-\rho t}dt = \int_0^\infty N(t)\frac{[c(t)^{\epsilon_C}(1-L(t))^{\epsilon_L}]^{1-\sigma}-1}{1-\sigma}e^{-\rho t}dt, \tag{5.10}$$

where $\rho > 0$ is the pure rate of time preference, $u(t)$ represents the felicity function, and $c(t)$ is per capita consumption of the final good. We normalize the total amount of time to unity so that $1 - L(t)$ reflects leisure. The parameter $\sigma > 0$ represents the inverse of the intertemporal elasticity of substitution. Preference weights for consumption and leisure are given by $\epsilon_C > 0$ and $\epsilon_L > 0$, respectively. The felicity function is assumed to be jointly concave in per capita consumption and leisure.

[9] For more detail see Aghion and Howitt (1998, p. 88). The derivation of equation (5.8) is given in Appendix 5.A.

[10] This result is given in Appendix 5.A.

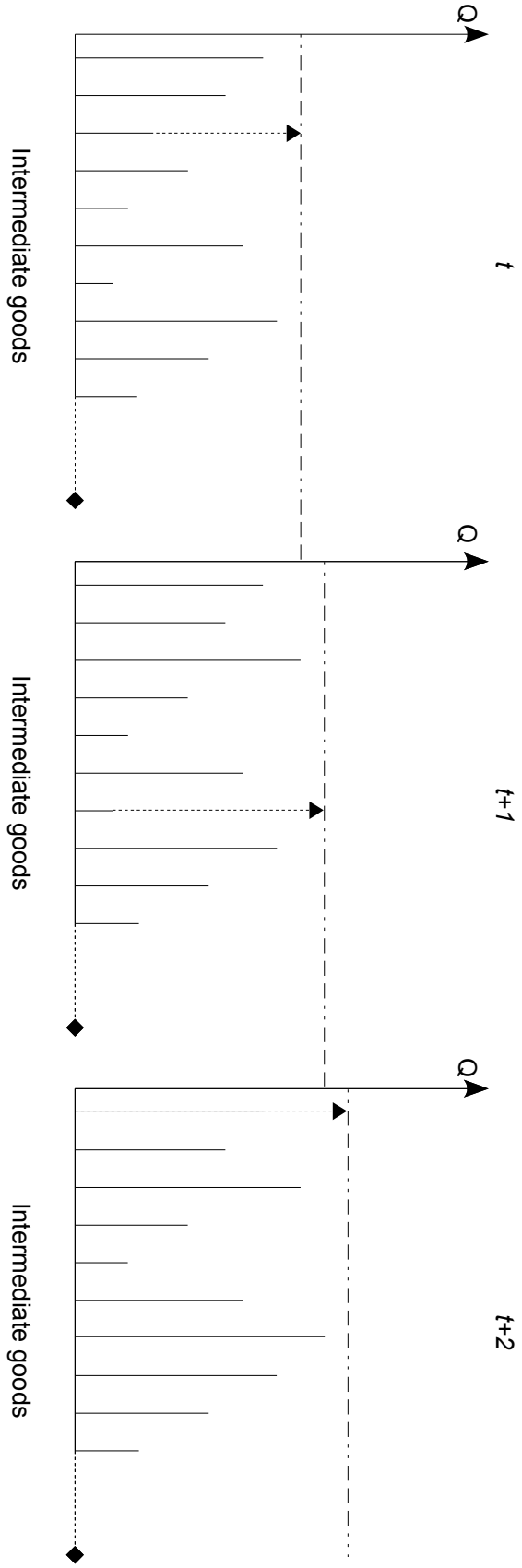


Figure 5.1: The Process of Quality Improvements

The representative household receives income from labor and claims on assets $A(t)$ and government bonds $B(t)$.[11] Since we have a closed economy, assets equal the sum of patent values $A(t) \equiv \int_0^1 V_i(t|Q_i(t))di$. Moreover, households receive lump-sum transfers $T(t) > 0$ from the government. The budget constraint of the household is then given by

$$\dot{A}(t) + \dot{B}(t) = r(t)A(t) + r_B(t)B(t) + (1-\tau_L)w(t)H(t) - (1+\tau_C)C(t) + T(t), \tag{5.11a}$$

where $r_B(t)$ is the rate of return on government bonds, $C(t) \equiv c(t)N(t)$ is aggregate consumption, and $H(t) \equiv L(t)N(t)$ is aggregate labor. Labor income is taxed at rate τ_L and consumption at rate τ_C. The per capita budget constraint of the household is given by

$$\dot{a}(t)+\dot{b}(t) = (r(t)-n)a(t)+(r_B(t)-n)b(t)+(1-\tau_L)w(t)L(t)-(1+\tau_C)c(t)+T(t)/N(t), \tag{5.11b}$$

where $a(t) \equiv A(t)/N(t)$ and $b(t) \equiv B(t)/N(t)$, are assets per capita and government bonds per capita, respectively. Households choose consumption, labor, assets, and government bonds to maximize utility (5.10) subject to the per capita budget constraint (5.11b). The first-order conditions for this problem are

$$\epsilon_C c(t)^{-1} \left(c(t)^{\epsilon_C}(1-L(t))^{\epsilon_L}\right)^{1-\sigma} = \lambda(t)(1+\tau_C), \tag{5.12a}$$

$$\epsilon_L (1-L(t))^{-1} \left(c(t)^{\epsilon_C}(1-L(t))^{\epsilon_L}\right)^{1-\sigma} = \lambda(t)(1-\tau_L)w(t), \tag{5.12b}$$

$$\lambda(t)(r(t)-n) = \lambda(t)(\rho-n) - \dot{\lambda}(t), \tag{5.12c}$$

$$\lambda(t)(r_B(t)-n) = \lambda(t)(\rho-n) - \dot{\lambda}(t), \tag{5.12d}$$

where $\lambda(t)$ is the shadow price of assets and government bonds. The transversality conditions are given by

$$\lim_{t\to\infty} \lambda(t)A(t)e^{-\rho t} = 0, \quad \text{and} \quad \lim_{t\to\infty} \lambda(t)B(t)e^{-\rho t} = 0. \tag{5.13}$$

[11] Government bonds are assumed to be perpetuities that every period pay out a coupon equal to one unit of output. The nominal value of the stock of bonds $B(t)$ is defined as the number of bonds multiplied by their price $p_B(t)$ defined in terms of the numeraire. The return on bonds is given by $r_B(t) \equiv (1+\dot{p}_B(t))/p_B(t)$. We choose this specification to abstract from transitional dynamics in portfolio shares associated with fixed-price bonds; see Turnovsky (2000b, p. 438).

Combining equations (5.12c) and (5.12d) gives the no-arbitrage condition $r_B(t) = r(t)$, which says the return on assets should equal the return on government bonds.

5.2.5. Government

Government expenditures are interest payments on outstanding bonds $r_B(t)B(t)$, lump-sum transfers to households $T(t)$, and other expenditures defined by $G(t) \equiv \omega_G Y(t)$, which says that $G(t)$ is a constant fraction of output $(0 < \omega_G < 1)$. Revenues of the government consist of taxes on consumption $\tau_C C(t)$, capital income $\tau_X(Y(t) - w(t)H(t))$, and labor income $\tau_L w(t)H(t)$. Moreover, $s_Z Z(t)$ measures the amount of foregone revenues by research effort stimulating tax incentives. Any fiscal deficit has to be financed by issuing bonds. Taking into account the no-arbitrage condition $r_B(t) = r(t)$, the periodic budget constraint of the government becomes

$$\dot{B}(t) = r(t)B(t) + T(t) + \omega_G Y(t) - \tau_L w(t)H(t) - \tau_C C(t) - \tau_X(Y(t) - w(t)H(t)) + s_Z Z(t). \quad (5.14)$$

5.2.6. Balanced Growth Equilibrium

We define the balanced growth equilibrium as a situation where aggregate consumption, research expenditures, intermediate goods expenditures, and output all grow at the same rate while labor supply is constant:

$$g = \frac{\dot{C}(t)}{C(t)} = \frac{\dot{Z}(t)}{Z(t)} = \frac{\dot{X}(t)}{X(t)} = \frac{\dot{Y}(t)}{Y(t)}, \quad \text{and} \quad \dot{L}(t) = 0,$$

where g is the constant growth rate of the economy in the balanced growth equilibrium and $X(t) \equiv \int_0^1 \psi Q_i(t)^\theta x_i(t|Q_i(t))di$. The evolution of labor supply over time is given by[12]

$$\dot{L}(t) = \frac{(v-1)(\alpha-1)(1-\epsilon_\beta) + \theta\alpha(1-(1-\sigma)\epsilon_C)}{(\alpha-1)(1-\epsilon_\beta)(1-(1-\sigma)(\epsilon_C+\epsilon_L))}(L(t)-1)(\gamma_P - \gamma_Q) \quad (5.15)$$

[12]The derivation of equation (5.15) is given in Appendix 5.A.

with

$$\gamma_P \equiv \frac{(\alpha-1)(1-\epsilon_\beta)}{(v-1)(\alpha-1)(1-\epsilon_\beta)+\theta\alpha(1-(1-\sigma)\epsilon_C)}\left(\xi\frac{1-\tau_X}{1-s_Z}\frac{v-1+\theta}{\epsilon_\beta}Q_N(t)L(t)-\rho\right), \tag{5.16a}$$

$$\gamma_Q \equiv \frac{\xi}{\alpha}Q_N(t)L(t)\left(1-\omega_G-\alpha(1-\tau_X)\frac{\epsilon_\beta-1}{\epsilon_\beta}-\frac{\epsilon_C}{\epsilon_L}\frac{1-\tau_L}{1+\tau_C}(1-\alpha)\frac{1-L(t)}{L(t)}\right), \tag{5.16b}$$

where $\xi \equiv \frac{\eta}{v-1}\left(\frac{v-1}{v-1+\theta}\right)^{\frac{\alpha}{(\alpha-1)(1-\epsilon_\beta)}}\left(\frac{\epsilon_\beta}{\epsilon_\beta-1}\frac{\psi}{1-\tau_X}\right)^{\frac{\alpha}{\alpha-1}}$ and

$$Q_N(t) \equiv Q(t)^{\frac{\theta\alpha}{(\alpha-1)(1-\epsilon_\beta)}-\phi}N(t). \tag{5.17}$$

From equation (5.15) it can be seen that $\dot{L}(t)=0$ when $\gamma_P=\gamma_Q$. Using equations (5.1), (5.2), (5.5), (5.8), and $P(t)=\left(\int_0^1 p_i(t|Q_i(t))^{1-\epsilon_\beta}Q_i(t)^{\theta\epsilon_\beta}di\right)^{\frac{1}{1-\epsilon_\beta}}$, output can be given by

$$Y(t)=\left(\frac{v-1}{v-1+\theta}\right)^{\frac{\alpha}{(\alpha-1)(1-\epsilon_\beta)}}\left(\frac{\epsilon_\beta}{\epsilon_\beta-1}\frac{\psi}{1-\tau_X}\right)^{\frac{\alpha}{\alpha-1}}\frac{L(t)}{\alpha}Q(t)^{\frac{\theta\alpha}{(\alpha-1)(1-\epsilon_\beta)}}N(t).$$

Given that γ_Q denotes the growth rate of the leading-edge quality $\frac{\dot{Q}(t)}{Q(t)}$, the growth rate of output in the balanced growth equilibrium is $g=\frac{\theta\alpha}{(\alpha-1)(1-\epsilon_\beta)}\gamma_Q+n$, which is only constant as long as $Q_N(t)$ is constant; see equations (5.16a) and (5.16b). The evolution of $Q_N(t)$ over time is as follows:

$$\dot{Q}_N(t)=\left(\left(\frac{\theta\alpha}{(\alpha-1)(1-\epsilon_\beta)}-\phi\right)\gamma_Q+n\right)Q_N(t), \tag{5.18}$$

which implies that there are two cases in which $\dot{Q}_N(t)=0$.

In the first case, $\phi > \frac{\theta\alpha}{(\alpha-1)(1-\epsilon_\beta)}$ and $n>0$. For $\dot{Q}_N(t)$ to be zero, $\gamma_Q = n\left(\phi-\frac{\theta\alpha}{(\alpha-1)(1-\epsilon_\beta)}\right)^{-1}$ must hold. The growth rate of the economy in the balanced growth equilibrium is then given by $g=\phi n\left(\phi-\frac{\theta\alpha}{(\alpha-1)(1-\epsilon_\beta)}\right)^{-1}$. In this case, g does not depend on fiscal instruments of the government, for example, the tax incentives related to research effort s_Z, so that government policies cannot influence the growth rate of the economy in the balanced growth equilibrium. Let $\tilde{L}$ and $\tilde{Q}_N$ be the equilibrium values for which $\gamma_P=\gamma_Q$. Equations (5.16a) and (5.16b) show that these values are affected by fiscal instruments of the government, which means the

government can affect the level of output, so government policies have *temporary* effects on the growth rate of the economy during the transition toward the balanced growth equilibrium; this will be discussed in Section 5.2.7.

In the second case, $\phi = \frac{\theta\alpha}{(\alpha-1)(1-\epsilon_\beta)}$ and $n = 0$ so that $\tilde{Q}_N = 1$, and the growth rate of the economy in the balanced growth equilibrium is $g = \frac{\theta\alpha}{(\alpha-1)(1-\epsilon_\beta)}\gamma_P(\tilde{L}) = \frac{\theta\alpha}{(\alpha-1)(1-\epsilon_\beta)}\gamma_Q(\tilde{L})$. The equilibrium value of labor supply $\tilde{L}$ follows from equating (5.16a) and (5.16b). In this case, g depends on $\tilde{L}$, which can be influenced by the government so that government policies have *permanent* effects on the growth rate of the economy.

The balanced growth equilibrium in which government policies have temporary effects on growth (TEG) and the one in which they have permanent effects on growth (PEG) are respectively described by[13]

$$\left.\begin{aligned} g \quad &= \phi n \left(\phi - \tfrac{\theta\alpha}{(\alpha-1)(1-\epsilon_\beta)}\right)^{-1}, \\ &\gamma_P = \gamma_Q = n \left(\phi - \tfrac{\theta\alpha}{(\alpha-1)(1-\epsilon_\beta)}\right)^{-1} \Rightarrow \tilde{Q}_N, \\ &\gamma_P = \gamma_Q = n \left(\phi - \tfrac{\theta\alpha}{(\alpha-1)(1-\epsilon_\beta)}\right)^{-1} \Rightarrow \tilde{L}, \end{aligned}\right\} \quad \text{for TEG,} \qquad (5.19a)$$

$$\left.\begin{aligned} g \quad &= \tfrac{\theta\alpha}{(v-1)(\alpha-1)(1-\epsilon_\beta)+\theta\alpha(1-(1-\sigma)\epsilon_C)} \left(\xi \tfrac{1-\tau_X}{1-s_Z} \tfrac{v-1+\theta}{\epsilon_\beta} \tilde{L} - \rho\right), \\ \tilde{Q}_N \quad &= 1, \\ &\gamma_P = \gamma_Q \Rightarrow \tilde{L}, \end{aligned}\right\} \quad \text{for PEG.} \qquad (5.19b)$$

Figure 5.2 gives a graphical representation of the equilibrium described by (5.19a). The dashed lines in the graphs, indicated by Γ_P, correspond to γ_P and are associated with portfolio balance equilibrium. Along these lines the return on consumption always equals the return on investment. The solid lines, indicated by Γ_Q, correspond to γ_Q and are associated with good market equilibrium. Along these lines, the aggregate resource constraint $Y(t) = C(t) + G(t) + X(t) + Z(t)$ and the intratemporal optimality condition between consumption and leisure are always satisfied.[14]

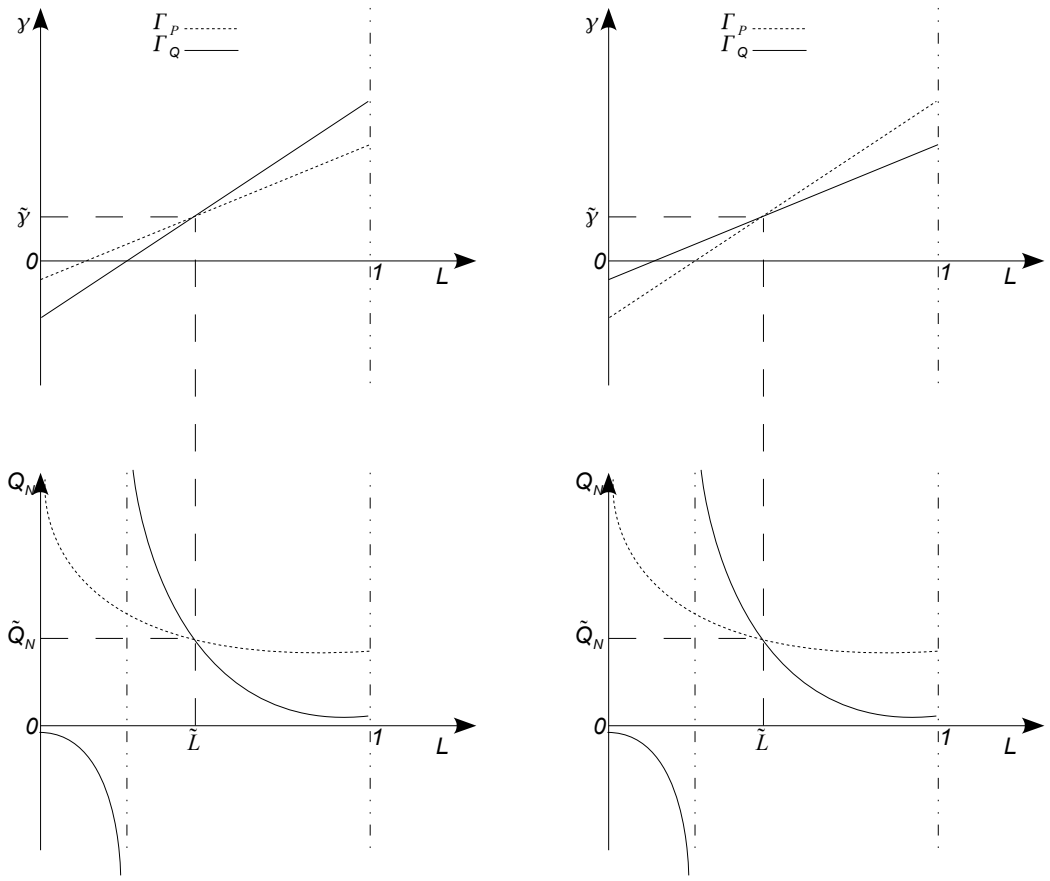
The top panel of the figure shows the two loci describing the relationship between γ_i and L conditional on Q_N, for $i \in \{P, Q\}$. When the two loci intersect, labor

[13]Basically, the TEG and PEG equilibria correspond to an endogenous growth model without and with scale effects, respectively.

[14]The intratemporal optimality condition between consumption and leisure says that the marginal rate of substitution between consumption and leisure equals its relative price.

Figure 5.2: TEG Equilibrium: $\phi > \frac{\theta\alpha}{(\alpha-1)(1-\epsilon_\beta)}$ and $n > 0$

(a) Locally Determinate (b) Locally Indeterminate



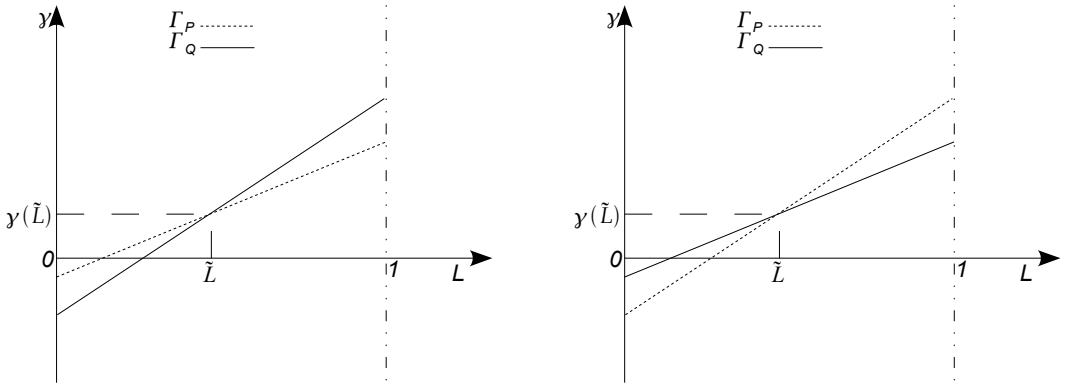
Notes: The dashed lines in the graphs correspond to Γ_P and are associated with portfolio balance equilibrium. The solid lines correspond to Γ_Q and are associated with good market equilibrium. In the balanced growth equilibrium $\tilde{\gamma} = n\left(\phi - \frac{\theta\alpha}{(\alpha-1)(1-\epsilon_\beta)}\right)^{-1}$.

supply is constant over time. Figures 5.2a and 5.2b only differ in the way these loci intersect, which determines the stability of the equilibrium. The bottom panel presents two loci describing the relationship between Q_N and L conditional on $\gamma_P = \gamma_Q = n\left(\phi - \frac{\theta\alpha}{(\alpha-1)(1-\epsilon_\beta)}\right)^{-1}$, both for γ_P and γ_Q. The top and bottom panel together determine the equilibrium values $\tilde{Q}_N$ and $\tilde{L}$.

Figure 5.3 shows the graphical representation of the equilibrium described by (5.19b). Since $\tilde{Q}_N = 1$ by the choice of parameter values, the equilibrium is solely represented by the two loci describing the relationship between γ_i and L, for $i \in \{P, Q\}$. The growth rate of the economy and corresponding equilibrium value of labor supply $\tilde{L}$ are determined by the intersection of these loci.

Figure 5.3: PEG Equilibrium: $\phi = \frac{\theta\alpha}{(\alpha-1)(1-\epsilon_\beta)}$ and $n = 0$

(a) Locally Determinate (b) Locally Indeterminate



Notes: The dashed lines in the graphs correspond to Γ_P and are associated with portfolio balance equilibrium. The solid lines correspond to Γ_Q and are associated with good market equilibrium.

5.2.7. Transitional Dynamics

Using equations (5.15)–(5.18) and $\gamma_P = \gamma_Q$ in equilibrium, the linearized dynamics are described by

$$\begin{bmatrix} \dot{L}(t) \\ \dot{Q}_N(t) \end{bmatrix} = \Delta \begin{bmatrix} L(t) - \tilde{L} \\ Q_N(t) - \tilde{Q}_N \end{bmatrix}, \tag{5.20}$$

where Δ is the Jacobian matrix with typical element δ_{ij}:

$$\delta_{11} \equiv \frac{(v-1)(\alpha-1)(1-\epsilon_\beta)+\theta\alpha(1-(1-\sigma)\epsilon_C)}{(\alpha-1)(1-\epsilon_\beta)(1-(1-\sigma)(\epsilon_C+\epsilon_L))}(\tilde{L}-1)\left(\frac{\partial\gamma_P}{\partial L}\bigg|_{\tilde{L},\tilde{Q}_N}-\frac{\partial\gamma_Q}{\partial L}\bigg|_{\tilde{L},\tilde{Q}_N}\right),$$

$$\delta_{12} \equiv \frac{(v-1)(\alpha-1)(1-\epsilon_\beta)+\theta\alpha(1-(1-\sigma)\epsilon_C)}{(\alpha-1)(1-\epsilon_\beta)(1-(1-\sigma)(\epsilon_C+\epsilon_L))}(\tilde{L}-1)\left(\frac{\partial\gamma_P}{\partial Q_N}\bigg|_{\tilde{L},\tilde{Q}_N}-\frac{\partial\gamma_Q}{\partial Q_N}\bigg|_{\tilde{L},\tilde{Q}_N}\right)<0,$$

$$\delta_{21} \equiv \left(\frac{\theta\alpha}{(\alpha-1)(1-\epsilon_\beta)}-\phi\right)\left(\frac{\partial\gamma_Q}{\partial L}\bigg|_{\tilde{L},\tilde{Q}_N}\right)\tilde{Q}_N<0,$$

$$\delta_{22} \equiv -n<0.$$

Since δ_{12}, δ_{21}, and δ_{22} are all negative, the TEG equilibrium is saddle path stable if the following condition holds:[15]

$$\frac{(v-1)(\alpha-1)(1-\epsilon_\beta)+\theta\alpha(1-(1-\sigma)\epsilon_C)}{(\alpha-1)(1-\epsilon_\beta)(1-(1-\sigma)(\epsilon_C+\epsilon_L))}(\tilde{L}-1)\left(\frac{\partial\gamma_P}{\partial L}\bigg|_{\tilde{L},\tilde{Q}_N}-\frac{\partial\gamma_Q}{\partial L}\bigg|_{\tilde{L},\tilde{Q}_N}\right)-n>0. \quad (5.21)$$

The condition in equation (5.21) also determines the stability of the PEG equilibrium where $\phi=\frac{\theta\alpha}{(\alpha-1)(1-\epsilon_\beta)}$ and $n=0$. In this case, the elements δ_{12}, δ_{21}, and δ_{22} are all zero so that the dynamics of the balanced growth equilibrium are given by $\dot{L}(t)=\delta_{11}(L(t)-\tilde{L})$. If $\delta_{11}>0$, then a positive deviation of labor supply from its steady-state value leads to a permanent deviation from this value. The balanced growth equilibrium is then locally unstable and, thus, locally determinate. Moreover, the economy is then always in its balanced growth equilibrium and there are no transitional dynamics. If $\delta_{11}<0$, then a positive deviation will force labor supply back to its initial steady-state value so that the balanced growth equilibrium is locally stable and, thus, locally indeterminate. Figures 5.3a and 5.3b give the situations in which the PEG equilibrium is locally determinate and indeterminate, respectively.

5.3. Analytical Results

In this section, we discuss the effects of changes in the fiscal instruments on the economy and the long-run government budget balance of the government, respec-

[15] When $\delta_{11}-n>0$, the determinant and trace of Δ are negative and positive, respectively, which means the equilibrium is saddle path stable.

tively.

5.3.1. Effects of Fiscal Policy on the Economy

We define fiscal policies as changes in tax rates τ_C, τ_L, and τ_X, changes in government expenditures ω_G, and changes in the generosity of the tax incentives with respect to research effort s_Z. From the definitions in (5.19), it follows that L and Q_N in the respective balanced growth equilibria are given by

$$\left.\begin{aligned} \tilde{L} &= \tilde{l}_{\text{TEG}}(\alpha, \epsilon_\beta, \epsilon_C, \epsilon_L, \rho, \sigma, v, \tau_C, \tau_L, \tau_X, s_Z, \omega_G, \theta, \phi, n,) \\ \tilde{Q}_N &= \tilde{q}_{\text{TEG}}(\alpha, \epsilon_\beta, \epsilon_C, \epsilon_L, \rho, \sigma, v, \tau_C, \tau_L, \tau_X, s_Z, \omega_G, \theta, \phi, n, \eta, \psi, \tilde{L}) \end{aligned}\right\} \quad \text{for TEG,}$$

$$\left.\begin{aligned} \tilde{L} &= \tilde{l}_{\text{PEG}}(\alpha, \epsilon_\beta, \epsilon_C, \epsilon_L, \rho, \sigma, v, \tau_C, \tau_L, \tau_X, s_Z, \omega_G, \theta, \eta, \psi) \\ \tilde{Q}_N &= 1 \end{aligned}\right\} \quad \text{for PEG.}$$

The steady-state, or long-run, effects of fiscal policies are obtained by fully differentiating the functions $\tilde{l}_{\text{TEG}}(\cdot)$, $\tilde{q}_{\text{TEG}}(\cdot)$, and $\tilde{l}_{\text{PEG}}(\cdot)$.[16] For now, we assume changes in government revenues or expenditures that follow from these fiscal policies are offset in a non-distorting way by adjusting lump-sum transfers to keep the budget balance of the government unchanged. For the TEG equilibrium, the effects are

$$\begin{aligned} \frac{d\tilde{L}}{di} < 0 \quad \text{and} \quad \frac{d\tilde{Q}_N}{di} > 0 \quad \text{for } i \in \{\tau_C, \tau_L, \tau_X\}, \\ \frac{d\tilde{L}}{di} > 0 \quad \text{and} \quad \frac{d\tilde{Q}_N}{di} < 0 \quad \text{for } i \in \{\omega_G, s_Z\}, \end{aligned}$$

which says that increases in tax rates lead to a decrease in labor supply and a decrease in the relative quality used in production.[17] On the other hand, an increase in government expenditures and more generous tax incentives with respect to research effort lead to an increase in both labor supply and the relative quality of intermediate goods used in production.

The effects for the PEG equilibrium are less straightforward. In gen-

[16] From (5.19) it follows that $\tilde{L}$ and $\tilde{Q}_N$ are described by two equations with two unknowns in the TEG equilibrium and by one equation with one unknown in the PEG equilibrium. Although we can solve explicitly for $\tilde{L}$ and $\tilde{Q}_N$ in both equilibria, the resulting expressions are too large to show them here.

[17] An increase in $\tilde{Q}_N$ corresponds to a decrease in the leading-edge quality Q relative to N; see equation (5.17).

eral, the effects of fiscal policies on labor supply are given by $\frac{d\tilde{L}}{di} = \left(\frac{\partial \gamma_Q}{\partial i}\Big|_{\tilde{L}} - \frac{\partial \gamma_P}{\partial i}\Big|_{\tilde{L}} \right) \left(\frac{\partial \gamma_P}{\partial L}\Big|_{\tilde{L}} - \frac{\partial \gamma_Q}{\partial L}\Big|_{\tilde{L}} \right)^{-1}$ for $i \in \{\tau_C, \tau_L, \tau_X, \omega_G, s_Z\}$; see equation (5.19b). If the condition in equation (5.21) is satisfied, then the effects of fiscal policies for the PEG equilibrium are in line with those of the TEG equilibrium:

$$\begin{aligned} &\frac{d\tilde{L}}{di} < 0 \quad \text{and} \quad \frac{dg}{di} < 0 \quad \text{for } i \in \{\tau_C, \tau_L, \tau_X\}, \\ &\frac{d\tilde{L}}{di} > 0 \quad \text{and} \quad \frac{dg}{di} > 0 \quad \text{for } i \in \{\omega_G, s_Z\}. \end{aligned}$$

In this case, increases in tax rates lead to a decrease in labor supply and, in contrast to the TEG equilibrium, a permanent lower growth rate of the economy. An increase in government expenditures or more generous tax incentives with respect to research effort lead to an increase in both labor supply and the growth rate of the economy. The effects are the opposite if equation (5.21) is not satisfied.

For the calibrated model and numerical illustrations in Section 5.3, equation (5.21) is always satisfied.[18] Henceforth, we assume that this equation is satisfied. In this case, there are no transitional dynamics in the PEG equilibrium, and transitional dynamics in the TEG equilibrium are given by solving (5.20):

$$\begin{aligned} L(t) &= (1 - e^{\mu t})\, \tilde{L}(\infty) + e^{\mu t} L(0), \\ Q_N(t) &= (1 - e^{\mu t})\, \tilde{Q}_N(\infty) + e^{\mu t} Q_N(0), \end{aligned}$$

where μ is the stable characteristic root of matrix Δ, and $\tilde{L}(\infty)$ and $\tilde{Q}_N(\infty)$ are long-run equilibrium values. Moreover, $L(0) = L(\infty) + (Q_N(0) - \tilde{Q}_N(\infty)) \frac{\delta_{12}}{\mu - \delta_{11}}$ so that the short-run response of labor supply is larger in absolute terms than its long-run response. We proceed by discussing the effects in more detail.

For the TEG equilibrium, the short-run and long-run qualitative effects of more generous tax incentives with respect to research effort are given in Figures 5.4a and 5.4b, respectively. In the short run, an increase in s_Z leads to an increase in the return on research effort for the given leading-edge quality, which results in an upward

[18] Itaya (2008), however, shows that in an endogenous growth model with elastic labor supply and environmental externalities that are more than proportionally increasing with output an indeterminate balanced growth equilibrium may occur.

rotation of Γ_P in the upper panel of Figure 5.4a. The higher return on research effort leads to a shift of resources from consumption to research effort, and labor supply increases accordingly to ensure that both the aggregate resource constraint and the intratemporal optimality condition between consumption and leisure are satisfied.[19] The increase in labor supply leads to an increase in the growth rate in the short run. From the bottom panel of Figure 5.4a, it can be seen that both the short-run leading-edge quality and labor supply are incompatible with a balanced growth equilibrium under the more generous tax incentives.

[19]The intratemporal optimality condition between consumption and leisure is obtained by dividing equations (5.12a) by (5.12b). In general, there is a inverse relationship between consumption and labor supply, which depends among others on the relative utility weights of consumption and leisure, the relative taxation of consumption and wage income, and the production elasticity of labor. This relationship is captured by the slope of Γ_Q in the upper panel of Figure 5.4a. The relationship is not necessarily strictly linear though; see Turnovsky (2000a) and Van Oudheusden (2009).

Figure 5.4: TEG Equilibrium: Short-run and Long-run Effects of Fiscal Policies

(a) $ds_Z > 0$: $t = 0$ (b) $ds_Z > 0$: $t = \infty$

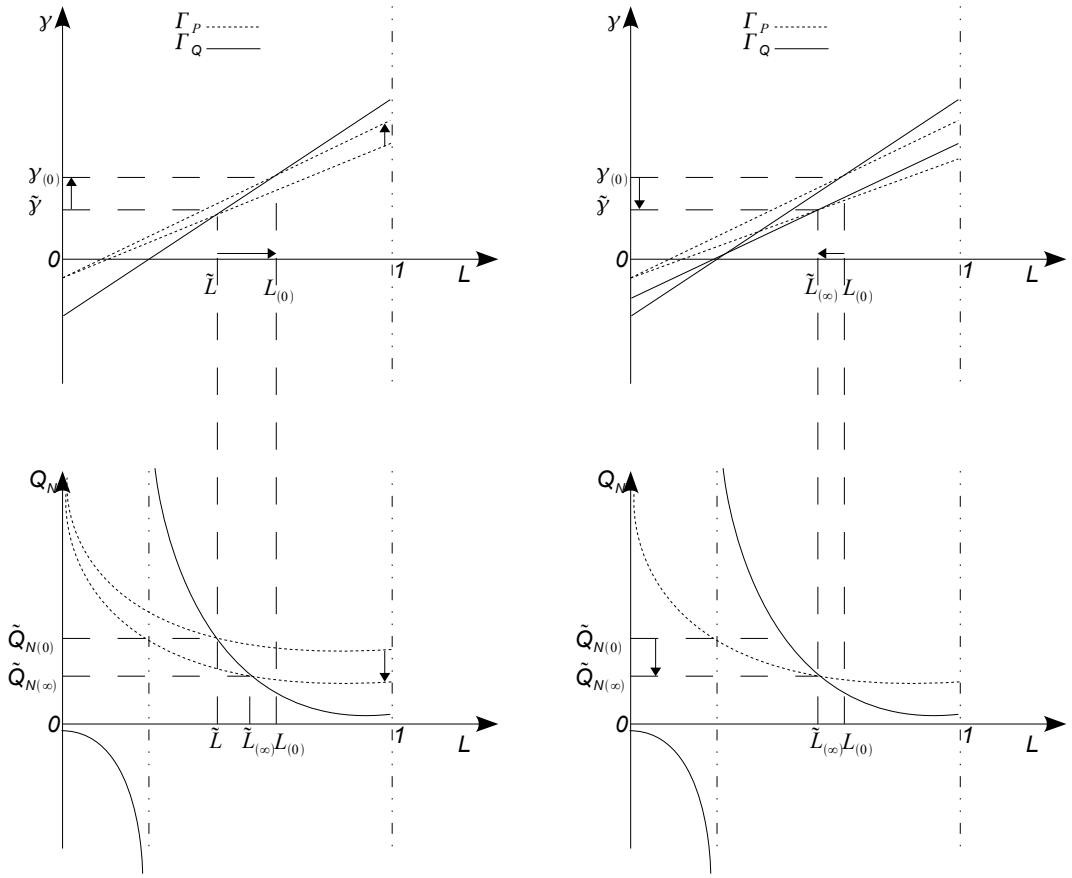
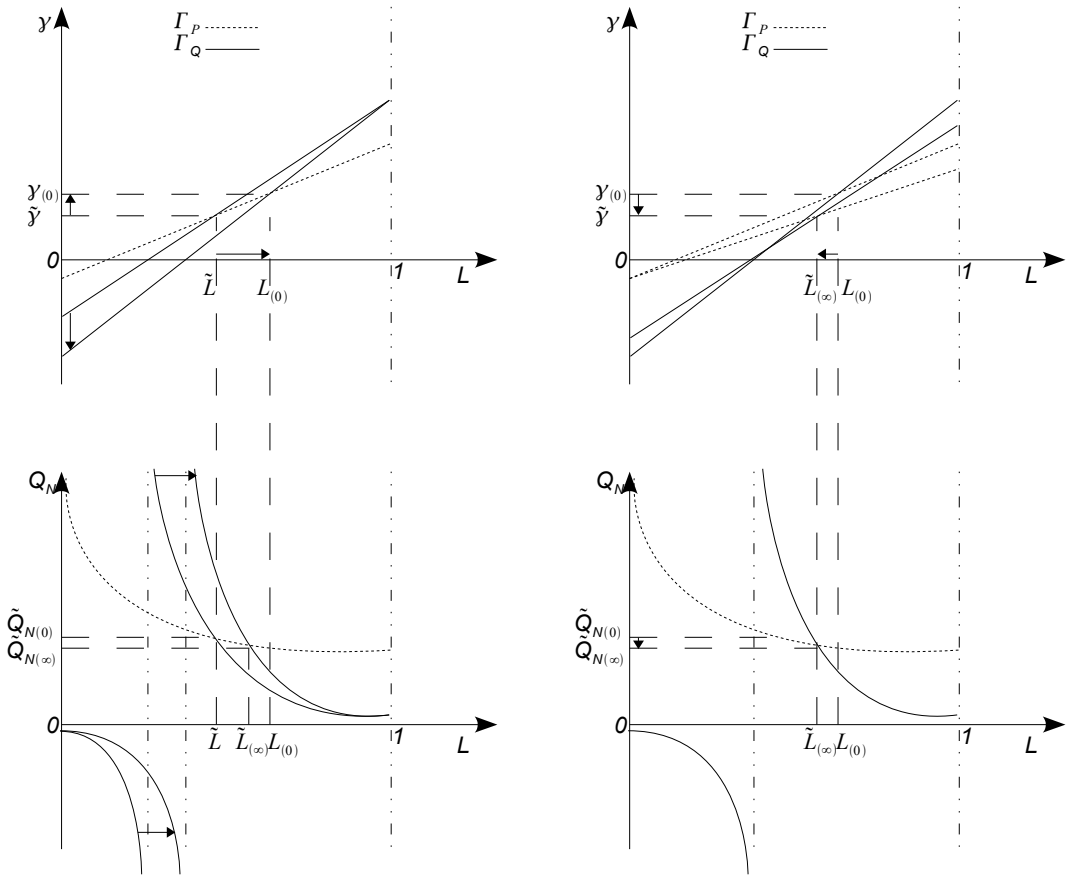


Figure 5.4: TEG Equilibrium: Short-run and Long-run Effects of Fiscal Policies (continued)

(c) $d\tau_L < 0$: $t = 0$ (d) $d\tau_L < 0$: $t = \infty$



Notes: The dashed lines in the graphs correspond to Γ_P and are associated with portfolio balance equilibrium. The solid lines correspond to Γ_Q and are associated with good market equilibrium. In the balanced growth equilibrium $\tilde{\gamma} = n\left(\phi - \frac{\theta\alpha}{(\alpha-1)(1-\epsilon_\beta)}\right)^{-1}$. Figures 5.4c and 5.4d also capture the effects of a lower tax rate on consumption.

The short-run increase in research effort leads to a higher growth of the leading-edge quality and, since population growth does not change, a decrease in Q_N. The return on research effort, however, decreases with the leading-edge quality since $\phi > \frac{\theta\alpha}{(\alpha-1)(1-\epsilon_\beta)}$, which is reflected by the downward rotation of Γ_P in the upper panel of Figure 5.4d. This decrease in the return on research effort also means that more labor is needed to produce the same amount of research effort, which results in a

clockwise rotation of Γ_Q in the upper panel of Figure 5.4b. Both effects imply a shift of resources from research effort to consumption and a corresponding reduction in labor supply so that research effort and the decline in Q_N decrease over time until the new equilibrium is reached; see the bottom panel of Figure 5.4b. In the new equilibrium, the growth rate of the economy returns to its balanced growth level.

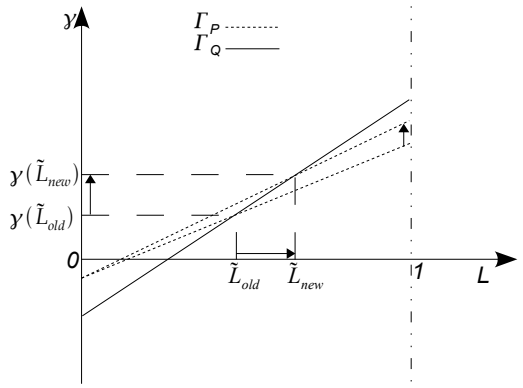
The qualitative effects of a lower tax rate on labor income, or equivalently a lower tax rate on consumption, are as follows. A decrease in τ_L makes consumption relatively cheap compared to leisure so that, for the current amount of labor supply, consumption has to increase to satisfy the aggregate resource constraint and the intratemporal optimality condition between consumption and leisure, which is represented by a downward rotation of Γ_Q in the upper panel of Figure 5.4c. As a consequence of the rise in consumption for the given amount of labor supply, the return on consumption falls below the return on research effort, which leads to a shift of resources from consumption to research effort and a corresponding increase in labor supply and the growth rate of the economy in the short run. The short-run leading-edge quality and labor supply are again incompatible with a balanced growth equilibrium under the lower tax rate on labor income; see the lower panel of Figure 5.4c.

The transition toward the long-run equilibrium is the same as described above and is presented in Figure 5.4d. Recall that the mechanism behind the transitional dynamics follows from the negative relationship between the return on research effort and the leading-edge quality; see the discussion in Section 5.2.3. In the PEG equilibrium, this is not the case since $\phi = \frac{\theta\alpha}{(\alpha-1)(1-\epsilon_\beta)}$, which implies that the return on research effort is independent of the leading-edge quality. This independency implies that the effects of fiscal policies in the PEG equilibrium are the same as the short-run effects in the TEG equilibrium; see Figures 5.5a and 5.5b. For a higher government expenditures-to-output ratio and a lower tax rate on capital income, we therefore limit the analysis of the qualitative effects to the PEG equilibrium.

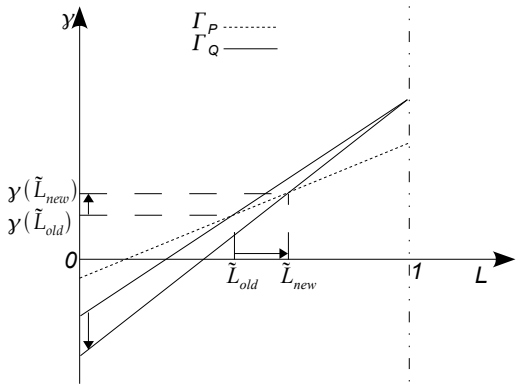
A higher government expenditures-to-output ratio increases the claim of the government on resources from the private sector. Given labor supply, and consumption following from the intratemporal optimality condition between consumption and

Figure 5.5: PEG Equilibrium: Short-run and Long-run Effects of Fiscal Policies

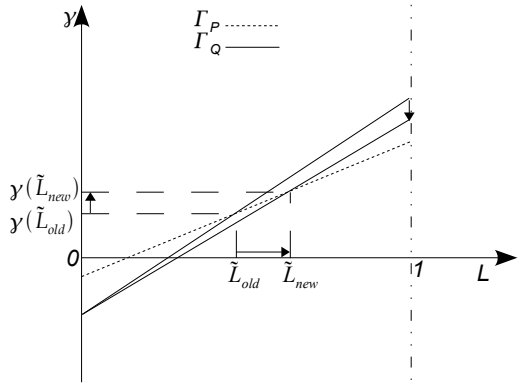
(a) $ds_Z > 0$



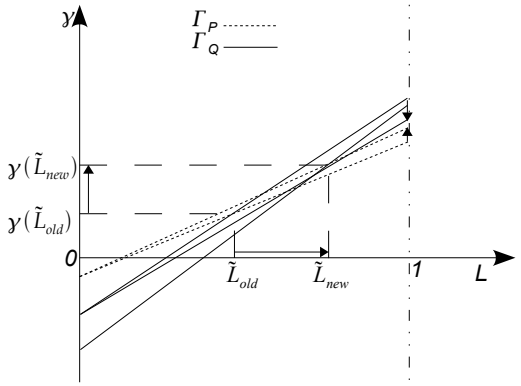
(b) $d\tau_L < 0$, $d\tau_C < 0$



(c) $d\omega_G > 0$



(d) $d\tau_X < 0$



Notes: The dashed lines in the graphs correspond to γ_P and are associated with portfolio balance equilibrium. The solid lines correspond to γ_Q and are associated with good market equilibrium.

leisure, this results in too little research effort given its return. This situation is represented by a downward rotation of Γ_Q in Figure 5.5c. As a result, resources flow from consumption to research effort and labor supply increases accordingly, leading to an increase in the growth rate of the economy.

The qualitative effects of a decrease in the capital income tax rate are given in Figure 5.5d. A decrease in τ_X leads to a higher return on research effort, which is shown by the upward rotation of Γ_P. Moreover, it increases the demand for intermediate goods, which results in too little research effort given labor supply. This situation is represented by the downward and counterclockwise rotation of Γ_Q. Both effects lead to a shift of resources from consumption toward research effort, which implies an increase in labor supply and the growth rate of the economy.

5.3.2. Effects of Fiscal Policy on the Government Budget Balance

The fiscal policies, and resulting changes in consumption, research effort, and labor supply also, effect the budget balance of the government. Studies that look at the feedback effects of fiscal policies using calibrated general equilibrium frameworks differ in the way they include the budget balance of the government. They assume either a periodically balanced government budget or an intertemporal government budget constraint that has to be satisfied, where the former has the disadvantage that it rules out financing schemes involving changes in the debt of the government.[20] We follow the latter approach since we want to analyze the consequences of the fiscal policies on the sustainability of the government budget in the long run. The long-run government budget balance is given by the intertemporal budget constraint of the government:

$$D \equiv \frac{\tau_C C(0) + \tau_L w(0)H(0) + \tau_X(Y(0) - w(0)H(0)) - s_Z Z(0) - \omega_G Y(0) - T(0)}{\tilde{r} - \tilde{g}} - B(0),$$

[20]For example, studies that assume a periodically balanced government budget are Mankiw and Weinzierl (2006), Zeng and Zhang (2007), and Itaya (2008), and analyses that look at the intertemporal budget balance of the government are Ireland (1994), Bruce and Turnovsky (1999), and Novales and Ruiz (2002).

where we make use of the customary No-Ponzi Game condition $\lim_{t\to\infty} B(t)e^{-\int_0^t r(t')dt'} = 0$.[21] If $D < 0$, then the net present value of government revenues minus the net present value of government expenditures is insufficient to pay off the initial public debt, and vice versa. The intertemporal budget constraint of the government is balanced if $D = 0$.

There are different approaches in the dynamic scoring literature to measure the feedback effects of fiscal policies on the government budget. Mankiw and Weinzierl (2006), Trabandt and Uhlig (2009), Strulik and Trimborn (2012), and Scrimgeour (2010) analyze the degree of self-financing of tax cuts and focus on the dynamic feedback effects on government revenues. In these analyses, government budgets are balanced by letting lump-sum transfers adjust, where lower transfers imply a replacement of distortionary taxes with lump-sum taxes. Bruce and Turnovsky (1999) take a different approach and measure the feedback effects as the change in the present discounted value of lump-sum taxes needed for the intertemporal budget to be balanced. This approach shifts the attention from the effects on government revenues toward the effects on the government budget in general, including the effects on government expenditures and the growth rate of the economy.

One way we measure the feedback effects is by κ, which is defined as the percentage change in the transfer-to-output ratio T/Y needed for the intertemporal budget to be balanced. More specifically,

$$\kappa \equiv \frac{T(\infty)}{Y(\infty)} \left(\frac{T(0)}{Y(0)} \right)^{-1} - 1 \quad \text{such that} \quad \frac{\partial D}{\partial i} = 0 \quad \text{for} \quad i \in \{\tau_C, \tau_L, \tau_X, \omega_G, s_Z\},$$

where we assume that initially $D = 0$ and that the debt-to-output ratio cannot change. Since this approach takes into account the effects on both government revenues and expenditures, the return on assets, and the growth rate of the economy, it is in line with the approach of Bruce and Turnovsky (1999).

The above measure gives a good indication of the dynamic feedback effects of fiscal policies on the government budget. However, it is restrictive since the financing scheme is limited to the adjustment of transfers. Ireland (1994) proposes an alter-

[21] Variables with tildes, like $\tilde{r}$ and $\tilde{g}$, are equilibrium values.

native financing scheme where the path of transfers is predetermined but requires the assumption of a fixed debt-to-output ratio to be relaxed. If the path of transfers is predetermined, growth enhancing fiscal policies, such as lower distortionary tax rates, lead to a decline in the transfer-to-output ratio over time. This process frees up resources in the future that can be used to cover the initial loss in revenues caused by the lower tax rates. Since these resources come available over time, government debt is used to finance short-term fiscal deficits. If the present discounted value of these resources equals or is larger than the deterioration of the government budget and additional interest payments, the intertemporal budget of the government remains balanced or may even improve. In the latter situation, the fiscal policies lead to a dynamic Laffer effect. This financing scheme seems to be used only in frameworks where fiscal policies have permanent effects on growth, though the idea naturally extends to frameworks where they have only temporary effects.

Although it has the advantage that government expenditures do not have to decrease, the alternative finance scheme described above does not always lead to an improvement in the long-run government budget and may even lead to a situation where the intertemporal budget constraint is not satisfied.[22] Leeper and Yang (2008) introduce financing schemes where the intertemporal budget constraint is satisfied without having to rely on adjustments of transfers. More specifically, changes in the government budget as a result of fiscal policies are offset with a range of possible responses, such as changes in government expenditures or other distorting taxes. These offsetting policies may dampen or reverse the stimulating effects on the economy that the initial fiscal policies have brought forth.

We analyze the dynamic feedback effects of fiscal policies on the government budget under these three financing schemes. The first is the non-distorting financing scheme, where we adjust the transfer-to-output ratio to ensure the intertemporal budget constraint of the government is satisfied. In this case, we assume the debt-to-output ratio cannot be changed. Under the second financing scheme, the path of transfers is predetermined so that transfers cannot be lowered to improve the

[22]See Van Oudheusden (2009) for an overview of the mechanisms behind the dynamic Laffer effect and the conditions under which it may occur.

budget balance of the government. Temporary changes in the debt-to-output ratio, however, are allowed. We call this the non-distorting finance scheme with debt. Finally, we consider the distorting finance scheme, where we finance changes in the government budget by adjusting government expenditures or other distorting taxes.

Changes in welfare as a result of a fiscal policy are calculated as the percentage change in consumption, corresponding to the initial balanced growth equilibrium, necessary to obtain the same present discounted value of utility that follows from the fiscal policy. This percentage change is given by

$$\upsilon \equiv \frac{C_A(0)}{C(0)} \left(\frac{1-\tilde{L}_A}{1-\tilde{L}} \right)^{\frac{\epsilon_L}{\epsilon_C}} \left(\frac{\rho - \epsilon_C(1-\sigma)g}{\rho - \epsilon_C(1-\sigma)g_A} \right)^{\frac{1}{(1-\sigma)\epsilon_C}} - 1,$$

where the subscript A corresponds to values of the new balanced growth equilibrium. If υ is positive, then fiscal policies lead to a gain in welfare. A negative value of υ implies a deterioration in welfare as a result of fiscal policies.

5.4. Numerical Results

To quantify the dynamic feedback effects of fiscal policies on the government budget, we perform several numerical analyses for different economies. We want these economies to differ in the way they set tax rates since this allows us to verify whether our model is able to replicate fiscal stylized facts and, thus, can be used for quantitative analyses. Mendoza and Tesar (2005) use similar arguments for the choice of their economies, we therefore choose the same economies. More specifically, we calibrate our model for both the United Kingdom and an average of three major continental European economies, namely France, Germany, and Italy; hereafter defined as Continental Europe. These two economies differ in how they tax factor income. Our choice of parameters and variables, representative for these countries, is based on data over the period 1995–2006. We take averages over this period to control for business-cycle effects, and we calibrate the model at an annual frequency.

5.4.1. Calibration and Stylized Facts

All fiscal parameters and variables are taken from the data, while for the structural parameters of the model we refer to literature when data are unavailable.[23]

To pin down the initial tax rates for the economies, we use data on implicit tax rates, which are based on the method of Mendoza et al. (1994). The benefits of these tax rates are that they take into account various features of the tax system, such as the combined effects of tax credits, tax deductions, and statutory rates.[24] The tax rate on consumption is the same for both economies and is 18.90 percent. The economies, however, differ in their tax rates on factor income. In Continental Europe, labor income and capital income are taxed at 41.16 and 20.01 percent, respectively, and for the United Kingdom these rates are 25.04 and 23.81 percent, respectively.

We measure the generosity of the tax incentives with respect to research effort by making use of data on the B-index, which captures the elements of these tax incentives such as exemptions, allowances, credits, tax deferrals and rate reliefs. The index reflects before-tax income required to break even on one unit of research expenditures. We take one minus this index as the value for the parameter s_Z, which is 4.10 percent for Continental Europe and 7.85 percent for the United Kingdom; see Warda (2001) for details on the construction of the B-index.

The remaining fiscal parameters are the public expenditures-to-output ratio and the debt-to-output ratio. When restricted to consumption expenditures only, the public expenditures-to-output ratio is 20.51 percent for Continental Europe and 19.53 percent for the United Kingdom. Including investment expenditures of the government increases these ratios to 22.85 and 20.98 percent, respectively, which are used for the calibration. The debt-to-output ratio is 77.63 percent for Continental Europe, but it is only 43.73 percent for the United Kingdom. This difference can be explained by Italy, which has a debt-to-output ratio of over one hundred percent. However,

[23] The data are given in Table A.1, and the corresponding definitions and data sources are given in Table A.2. The data and their sources are in line with the calibration as performed by Trabandt and Uhlig (2011).

[24] See European Commission (2011, pp. 392–422) for a detailed overview of the exact definitions of the implicit tax rates and Trabandt and Uhlig (2011) for arguments for the use of these tax rates rather than marginal tax rates.

the debt-to-output ratio of both France and Germany exceeds that of the United Kingdom, so the inclusion of Italy does not change their relative position.

For Continental Europe, the population growth rate and the production elasticity of aggregate labor are 0.80 percent and 0.6467, respectively, and for the United Kingdom these values are 1.08 percent and 0.7083, respectively. Here, we use that the value of the production elasticity of aggregate labor equals the income share of labor since there is perfect competition in the final goods sector. Krueger (1999), however, argues that there is a lot of variation in the income share of labor depending on which definition of labor income is used. Therefore, we do not always restrict the value of the production elasticity of aggregate labor to be equal to the observed income shares of labor, but let it vary to match other variables with the data; see also Grossmann et al. (2010).

We set the inverse of the intertemporal elasticity of substitution σ to 2, which falls well within the range of estimates found by Attanasio and Weber (1993) and is a common value used in the literature.[25] The choice for the elasticity of substitution between intermediate goods ϵ_β is less straightforward. A number of studies relates this elasticity directly to the production elasticity of capital α, resulting in either unrealistic high markups or implausible income shares of production factors when calibrating the model; see Romer (1990), Jones (1995), Zeng and Zhang (2007), and Long and Pelloni (2011). We follow the literature that calibrates the parameters ϵ_β and α separately (i.e., Jones and Williams, 2000; Grossmann et al., 2010). These studies choose a value for ϵ_β such that the implied markup lies between 1.05 and 1.40. We set ϵ_β to 20 and aim at the lower bound of this range since Basu (1996) argues that estimates of mark-ups may be too large when failing to take into account variable utilization rates of production factors.

The parameters ϵ_C, ϵ_L, ϕ, ρ, η, ψ, and v have no real-world observable counterparts. We set ϵ_C to 1 and let ϵ_L adjust so that the share of the time endowment allocated to labor resulting from the model matches with the share observed in the

[25]For example, Turnovsky (2000a), Mendoza and Tesar (2005), Itaya (2008) and Trabandt and Uhlig (2011) use the same value for σ. In contrast, Mankiw and Weinzierl (2006) and Leeper and Yang (2008) set σ equal to unity, which falls outside the range of Attanasio and Weber (1993). Our model, however, is also compatible with this value for the intertemporal elasticity of substitution.

data.[26] In general, the relative weight of leisure to consumption ϵ_L/ϵ_C is used to obtain a value of $\tilde{L}$ of around 20 percent (Mendoza and Tesar, 2005, p. 190). Differences in the values of α, or the tax rate on consumption and labor, then lead to differences in the value of ϵ_L/ϵ_C. For example, Novales and Ruiz (2002), Mendoza and Tesar (2005), and Leeper and Yang (2008), who all have in common that α is 0.36, set ϵ_L/ϵ_C between 2 and 3. In contrast, Turnovsky (2000a) sets ϵ_L/ϵ_C to 0.3 and works with a value of α of 0.92.

We set ρ so that the interest payments of the government match with the data. The parameters η and ψ are chosen such to ensure that, at least initially, the share of the time endowment allocated to labor in the TEG and PEG equilibrium coincides; see $\tilde{l}_{\text{TEG}}(\cdot)$ and $\tilde{l}_{\text{PEG}}(\cdot)$. Finally, we use ϕ, v, and θ to match the output share of research expenditures and the growth rate of output per capita with the data. The parameter v, which is inversely related to the size of quality improvements on the quality ladder of an intermediate good, has to be large enough for monopoly pricing to exist, so we set v equal to 2.[27]

Table 5.1 summarizes the choices of parameters. The table compares the outcomes of our model with stylized facts observed in the data for different scenarios. These scenarios differ as follows. In the first scenario (I) , $1-\alpha$ is chosen under the assumption that the value of the production elasticity of labor equals the income share of labor, whereas in the second scenario (II), $1-\alpha$ adjusts so that the output share of consumption matches the data. In the third (III) and fourth (IV) scenario, we vary $1-\alpha$ to match output shares of the capital income tax revenues and labor income tax revenues, respectively.

By adjusting ϵ_L, the share of time endowment allocated to labor resulting from the model always matches with the one observed in the data. The resulting values of ϵ_L/ϵ_C lie between 2 and 3, which are common values in the literature. Moreover, the implied values of the Frisch elasticity of labor supply vary between 1.41 and 1.58.

[26]The share of time endowment allocated to labor L is calculated as the amount of hours per capita worked divided by the time endowment, which is set to 7200 (=20×360). Other calculations are possible, though the current share is similar to those aimed for in the literature; see Turnovsky (2000a), Mendoza and Tesar (2005), Leeper and Yang (2008), and Trabandt and Uhlig (2011).

[27]More specifically, the condition for monopoly pricing to exist is $v \leq \theta\left(\frac{1}{\epsilon_\beta-1}\right)\left(\ln\left(\frac{\epsilon_\beta}{\epsilon_\beta-1}\right)\right)^{-1}+1$. See also Barro and Sala-i-Martin (1999, p. 244) and Acemoglu (2009, p. 461).

Table 5.1: Comparing Stylized Facts

Economy	τ_C	τ_L	τ_X	s_Z	ω_G	B/Y	n	ρ	$1-\alpha$	EPL	ϵ_L	ϵ_F
Continental Europe I	0.1890	0.4116	0.2001	0.0410	0.2285	0.7763	0.0080	0.0360	0.6467	13.600	2.3423	1.5640
Continental Europe II	0.1890	0.4116	0.2001	0.0410	0.2285	0.7763	0.0080	0.0360	0.7986	12.250	2.3163	1.5734
Continental Europe III	0.1890	0.4116	0.2001	0.0410	0.2285	0.7763	0.0080	0.0360	0.7041	13.000	2.3312	1.5680
Continental Europe IV	0.1890	0.4116	0.2001	0.0410	0.2285	0.7763	0.0080	0.0360	0.5418	15.500	2.3699	1.5541
United Kingdom I	0.1890	0.2504	0.2381	0.0785	0.2098	0.4373	0.0108	0.0245	0.7083	6.5000	2.9201	1.4246
United Kingdom II	0.1890	0.2504	0.2381	0.0785	0.2098	0.4373	0.0108	0.0245	0.8630	6.0600	2.9431	1.4179
United Kingdom III	0.1890	0.2504	0.2381	0.0785	0.2098	0.4373	0.0108	0.0245	0.7391	6.4150	2.9259	1.4229
United Kingdom IV	0.1890	0.2504	0.2381	0.0785	0.2098	0.4373	0.0108	0.0245	0.5418	7.4400	2.8822	1.4356
												(Continued)
Constraint	Data	Data	Data	Data	Data	Data	Data	r_B	Various	Z/Y	L	Implied

Table 5.1: Comparing Stylized Facts (continued)

	Continental Europe					United Kingdom				
	Actual	I	II	III	IV	Actual	V	VI	VII	VIII
L	0.2275	0.2275	0.2275	0.2275	0.2275	0.2275	0.2275	0.2275	0.2275	0.2275
$g-n$	0.0105	0.0105	0.0105	0.0105	0.0105	0.0105	0.0105	0.0105	0.0105	0.0105
Output shares:										
C	0.5794	0.4640	0.5794	0.5075	0.3842	0.6497	0.5359	0.6479	0.5581	0.4153
$X+Z$	0.1721	0.3075	0.1921	0.2640	0.3873	0.1544	0.2543	0.1423	0.2321	0.3749
Z	0.0391	0.0391	0.0391	0.0391	0.0391	0.0432	0.0432	0.0432	0.0432	0.0432
T	0.1769	0.1584	0.2123	0.1787	0.1211	0.1327	0.1162	0.1392	0.1207	0.0913
$r_B B$	0.0442	0.0442	0.0442	0.0442	0.0442	0.0268	0.0268	0.0268	0.0268	0.0268
$T+r_B B+G$	0.4262	0.4311	0.4850	0.4515	0.3938	0.3548	0.3528	0.3758	0.3573	0.3279
revenues: τ_C	0.1076	0.0877	0.1095	0.0959	0.0726	0.1167	0.1013	0.1224	0.1055	0.0785
revenues: τ_L	0.2230	0.2662	0.3287	0.2898	0.2230	0.1357	0.1774	0.2161	0.1851	0.1357
revenues: τ_X	0.0592	0.0707	0.0403	0.0592	0.0917	0.0621	0.0695	0.0326	0.0621	0.1091
revenues: total	0.3898	0.4246	0.4785	0.4449	0.3873	0.3145	0.3481	0.3712	0.3527	0.3233

Notes: Continental Europe is the average of France, Germany, and Italy. The data used for the calibration are based on the average over the period 1995–2006; see Table A.1. The term *EPL* denotes expected patent life. The parameters ϵ_C, ϵ_L, ϕ and ρ do not have observable equivalents in the data. We use the parameter ϕ to match the growth rate of our model, and the parameter ρ to match interest payments of the government. The parameters η and ψ are used to ensure L is the same in the TEG and PEG equilibrium. The values of ϵ_C, ϵ_L, σ, and L are used to determine the Frisch-elasticity of labor supply, which is given by $\epsilon_F \equiv \frac{\partial L}{\partial w}\frac{w}{L}\big|_{\partial U/\partial C} = \frac{1-L}{L}\frac{1-(1-\sigma)\epsilon_C}{1-(1-\sigma)(\epsilon_C+\epsilon_L)}$. In scenario (I), (II), (III), and (IV), $1-\alpha$ varies to match respectively the income share of labor, the output share of consumption, the output share of capital income tax revenues, and the output share of labor income tax revenues with the data.

These values are close to one, which is the value used by House and Shapiro (2006), Strulik and Trimborn (2012), and Trabandt and Uhlig (2011). In contrast to these analyses, however, our value for the Frisch elasticity of labor supply follows endogenously from the model and cannot be picked.[28] Although the values implied by the model are higher than estimates based on micro data, we think they are plausible given the "major discrepancies between the micro evidence and the assumptions on which the stylized dynamic models are based" (Browning et al., 1999, p. 545) and the downward bias in the micro estimates (Domeij and Flodén, 2006).

To match the growth rate of output per capita to the data, we adjust ϕ, v, and θ in such a way that the output share of research expenditures also matches with the data.[29] Given that these parameters have no real-world counterparts, we look

[28]More precisely, House and Shapiro (2006) have separable preference and Strulik and Trimborn (2012) and Trabandt and Uhlig (2011) use constant Frisch elasticity preferences. Trabandt and Uhlig (2011) also consider the case where the Frisch elasticity of labor supply does depend on the share of time endowment allocated to labor and has value of 3 in line with Prescott (1996). We can replicate this case in our model by setting $\sigma = 1$.

[29]Basically, we fix one of the parameters, v, and let the other vary. Changing the value of v

at the corresponding expected lifetime of a patent, which ranges from six years to 15.5 years. These values are well in the range of values found by Mansfield et al. (1981) and Caballero and Jaffe (1993); see also Jones and Williams (2000). An alternative strategy would be to fix the expected lifetime of a patent and compare the corresponding output share of research expenditures with the data. However, we do not pursue this approach since Jones and Williams (2000) and Grossmann et al. (2010) argue that statistics on research expenditures do not completely capture the true amount of research expenditures.

By construction, we cannot replicate the share of consumption and investment in output exactly since our model assumes a closed economy. More specifically, the observed sum of consumption, government expenditures, and investment in Continental Europe falls short of output when not taking into account net exports. This means the sum of output shares of consumption and investment resulting from the model will always differ from the observed sum in the data. For Continental Europe, this difference amounts to 2.00 percentage points, and for the United Kingdom this is -1.39 percentage points.

In general, we find that our model underpredicts the output share of consumption. Since the output share of government expenditures is determined by the data, we overpredict the investment share of output. This outcome may be explained by the inclusion of durable consumption goods in the data on consumption, which could be seen as investment; see Trabandt and Uhlig (2011). The best fit in terms of the consumption and investment shares in output is obtained in the scenarios where we choose $1 - \alpha$ such that the output share of consumption exactly matches. The implied income share of labor in this case is on average 79.86 percent for Continental Europe and on average 86.30 percent for the United Kingdom.

To measure the fit of our model in terms of the fiscal side of the economy, we calculate the transfer-to-output ratio necessary for the long-run government budget to be balanced and compare this ratio with its real-world counterpart. In addition, we look at the implied revenue shares in output for the various taxes and see whether

leads to a change in the value of the other parameters but does not influence the outcomes of the model.

they are in line with the shares as observed in the data. Note that by construction, we cannot replicate exact shares of all the fiscal parameters since we capture on average 95 percent of all expenditures but only 90 percent of all revenues.[30] This situation is incompatible with a positive stock of initial debt and a long-run government budget that is balanced. Given this problem, however, the model has a relatively good fit when comparing the implied and actual transfer-to-output ratio.

For the interest payments of the government to match the data, we adjust ρ. This leads to a value of 0.0360 for Continental Europe and 0.0245 for the United Kingdom. Both values are in the range of 0.02 (Agell and Persson, 2001; Mendoza and Tesar, 2005) and 0.04 (Turnovsky, 2000a; Mankiw and Weinzierl, 2006; Leeper and Yang, 2008) used in the literature. Since our model underpredicts the output share of consumption, it underpredicts the output share of consumption tax revenues as well. In general, the model overpredicts the output share of labor income tax revenues. We can remove this bias by adjusting $1-\alpha$, but the implied income share of labor is 54.18 percent, which seems rather low.[31] The overprediction of the output share of labor income tax revenues, however, is not a bias specific to our model, but it seems to be shared by a wider class of calibrated dynamic general equilibrium models; see Van Oudheusden (2009) and Trabandt and Uhlig (2011). There is no general pattern in the prediction of the output share of capital income tax revenues. To be certain that the tax bases following from our model correspond to the actual tax bases, we look at different scenarios when analyzing the dynamic feedback effects of fiscal policies on the government budget.

5.4.2. Feedback Effects of Fiscal Policies

Given our choice of parameters and variables for the different scenarios, we analyze the dynamic feedback effects of fiscal policies on the government budget. More

[30] For example, the sum of interest payments, transfers, consumptive government expenditures, and investment expenditures of the government are 94.19 percent of all government expenditures in the United Kingdom. At the same time, revenues from consumption taxes and taxes on labor income and capital income only make up 88.45 percent of all revenues. See Table A.1 for the data used in these calculations.

[31] The overprediction of the output share of labor income tax revenues is not too problematic since it mitigates the problem of the discrepancy between the government expenditures and revenues as described above.

specifically, we look at the effects of an unexpected and permanent one percentage point change in each of the fiscal instrument available to the government separately. Hereby, we look at a decrease in the various tax rates and an increase in the government expenditures-to-output share and generosity of tax incentives with respect to research effort.[32] When analyzing these fiscal policies, we make a distinction between a non-distorting financing scheme, a non-distorting financing scheme where we allow for debt-to-output ratio changes over time, and a distorting finance scheme where changes in the budget balance of the government are financed by adjusting expenditures or other distorting taxes.

5.4.2.1. Non-distorting Financing Scheme

Table 5.2 gives an overview of the effects on the economy of the fiscal policies in the case of the non-distorting financing scheme. For the TEG equilibrium, the table gives both the short-run and long-run effects on the growth rate per capita, a measure of the leading-edge quality used in production Q_N, the share of time endowment allocated to labor, and both the output shares of consumption and research expenditures. Since transitional dynamics are absent in the PEG equilibrium, these effects represent changes in balanced growth equilibrium values. For each fiscal policy, the model predicts the short-run effects in the TEG equilibrium to be the same as the effects in the PEG equilibrium. Any deviations between the two are caused by linearization of the dynamics around the balanced growth equilibrium. Table 5.2 shows that the magnitude of these deviations are around one-hundredths of a percent, so we are confident we capture the dynamics well.

Lowering the tax rate on capital income gives the largest increase in economic activity measured by the impact on the growth rate, either temporary or permanent, or the use of a relatively higher leading-edge quality in the new balanced growth equilibrium. This fiscal policy is followed by an increase in government expenditures, a lower tax rate on labor income, and more generous tax incentives with respect to research effort. A lower tax rate on consumption is the least effective way to boost the economy.

[32] Changes in the government expenditures-to-output ratio are henceforth referred to as changes in government expenditures for ease of notation.

Table 5.2: Effects of Fiscal Policies – Continental Europe

	$\Delta\tau_C = -0.01$			$\Delta\tau_L = -0.01$			$\Delta\tau_X = -0.01$			$\Delta s_Z = 0.01$			$\Delta\omega_G = 0.01$		
	TEG		PEG	TEG		PEG	TEG		PEG	TEG		PEG	TEG		PEG
	$t=0$	$t=\infty$		$t=0$	$t=\infty$		$t=0$	$t=\infty$		$t=0$	$t=\infty$		$t=0$	$t=\infty$	
Continental Europe I															
g	0.8214	0	0.8231	1.6411	0	1.6461	3.2486	0	3.2692	1.4088	0	1.4139	2.1149	0	2.1319
Q_N	0	-0.6497	0	0	-1.2909	0	0	-2.5308	0	0	-1.1106	0	0	-1.6650	0
L	0.6642	0.6540	0.6643	1.3281	1.3078	1.3284	0.6841	0.6443	0.6853	0.0861	0.0686	0.0864	1.7194	1.6932	1.7205
C/Y	-0.0132	0	-0.0133	-0.0260	0	-0.0264	-0.8795	-0.8287	-0.8811	-0.1113	-0.0887	-0.1117	-2.1881	-2.1554	-2.1895
Z/Y	0.1562	0	0.1578	0.3089	0	0.3135	1.8534	1.2502	1.8725	1.3216	1.0537	1.3263	0.3888	0	0.4044
κ		-2.9297	-2.9806		-4.0836	-4.1862		-2.7025	-2.9060		-0.3091	-0.3981		-7.5080	-7.6407
υ			0.0038			0.0075			0.0074			0.0023			-0.0121
Continental Europe II															
g	0.8046	0	0.8059	1.6078	0	1.6117	2.3250	0	2.3350	1.3633	0	1.3673	1.6562	0	1.6658
Q_N	0	-0.6497	0	0	-1.2909	0	0	-1.8590	0	0	-1.0971	0	0	-1.3334	0
L	0.6614	0.6540	0.6615	1.3226	1.3078	1.3228	0.3427	0.3213	0.3431	0.0676	0.0550	0.0678	1.3667	1.3514	1.3672
C/Y	-0.0096	0	-0.0097	-0.0190	0	-0.0192	-0.4420	-0.4146	-0.4427	-0.0874	-0.0711	-0.0876	-1.7453	-1.7261	-1.7459
Z/Y	0.1423	0	0.1435	0.2814	0	0.2851	1.6565	1.2502	1.6660	1.2949	1.0537	1.2987	0.2856	0	0.2946
κ		-2.7289	-2.7657		-3.7616	-3.8356		-1.1719	-1.2792		-0.2308	-0.2941		-5.6005	-5.6770
υ			0.0038			0.0076			0.0051			0.0024			-0.0096
Continental Europe III															
g	0.8140	0	0.8155	1.6264	0	1.6309	2.8460	0	2.8615	1.3888	0	1.3934	1.9144	0	1.9279
Q_N	0	-0.6497	0	0	-1.2909	0	0	-2.2426	0	0	-1.1048	0	0	-1.5221	0
L	0.6629	0.6540	0.6630	1.3257	1.3078	1.3259	0.5358	0.5048	0.5367	0.0780	0.0628	0.0783	1.5666	1.5456	1.5674
C/Y	-0.0116	0	-0.0117	-0.0229	0	-0.0232	-0.6899	-0.6502	-0.6910	-0.1009	-0.0812	-0.1013	-1.9967	-1.9703	-1.9977
Z/Y	0.1501	0	0.1515	0.2968	0	0.3010	1.7652	1.2502	1.7796	1.3097	1.0537	1.3141	0.3424	0	0.3549
κ		-2.8395	-2.8840		-3.9393	-4.0288		-2.0157	-2.1728		-0.2742	-0.3514		-6.6522	-6.7580
υ			0.0038			0.0075			0.0064			0.0024			-0.0110
Continental Europe IV															
g	0.8442	0	0.8465	1.6864	0	1.6929	4.2685	0	4.3073	1.4663	0	1.4731	2.6288	0	2.6577
Q_N	0	-0.6497	0	0	-1.2909	0	0	-3.2186	0	0	-1.1248	0	0	-2.0108	0
L	0.6678	0.6540	0.6680	1.3354	1.3078	1.3358	1.0519	0.9833	1.0547	0.1070	0.0830	0.1075	2.0950	2.0521	2.0971
C/Y	-0.0178	0	-0.0181	-0.0353	0	-0.0359	-1.3475	-1.2604	-1.3511	-0.1383	-0.1074	-0.1390	-2.6563	-2.6030	-2.6589
Z/Y	0.1752	0	0.1774	0.3465	0	0.3524	2.1046	1.2502	2.1398	1.3579	1.0537	1.3641	0.5228	0	0.5491
κ		-3.1724	-3.2420		-4.4741	-4.6143		-4.5561	-4.9121		-0.4049	-0.5282		-9.8186	-10.038
υ			0.0037			0.0074			0.0098			0.0023			-0.0148

(Continued)

Table 5.2: Effects of Fiscal Policies – United Kingdom

	$\Delta\tau_C = -0.01$			$\Delta\tau_L = -0.01$			$\Delta\tau_X = -0.01$			$\Delta s_Z = 0.01$			$\Delta\omega_G = 0.01$		
	TEG		PEG	TEG		PEG	TEG		PEG	TEG		PEG	TEG		PEG
	$t=0$	$t=\infty$		$t=0$	$t=\infty$		$t=0$	$t=\infty$		$t=0$	$t=\infty$		$t=0$	$t=\infty$	
United Kingdom I															
g	0.7195	0	0.7200	1.1302	0	1.1312	2.5678	0	2.5735	1.2737	0	1.2754	1.6060	0	1.6105
Q_N	0	-0.6543	0	0	-1.0242	0	0	-2.2998	0	0	-1.1532	0	0	-1.4517	0
L	0.6622	0.6586	0.6623	1.0404	1.0348	1.0405	0.4995	0.4869	0.4998	0.0751	0.0688	0.0752	1.4811	1.4731	1.4813
C/Y	-0.0046	0	-0.0046	-0.0072	0	-0.0072	-0.6388	-0.6228	-0.6392	-0.0964	-0.0883	-0.0966	-1.8759	-1.8660	-1.8762
Z/Y	0.0569	0	0.0574	0.0888	0	0.0898	1.5115	1.3125	1.5168	1.1977	1.0971	1.1993	0.1232	0	0.1273
κ		-4.6139	-4.6693		-6.0980	-6.1853		-3.0927	-3.2913		-0.4846	-0.5835		-10.237	-10.361
υ			0.0041			0.0065			0.0108			0.0046			-0.0097
United Kingdom II															
g	0.7153	0	0.7157	1.1236	0	1.1245	1.8995	0	1.9026	1.2533	0	1.2548	1.3181	0	1.3209
Q_N	0	-0.6543	0	0	-1.0242	0	0	-1.7206	0	0	-1.1415	0	0	-1.2009	0
L	0.6614	0.6586	0.6614	1.0392	1.0348	1.0392	0.2322	0.2249	0.2323	0.0618	0.0569	0.0619	1.2206	1.2155	1.2207
C/Y	-0.0036	0	-0.0036	-0.0056	0	-0.0056	-0.2978	-0.2884	-0.2980	-0.0794	-0.0731	-0.0795	-1.5500	-1.5436	-1.5501
Z/Y	0.0535	0	0.0539	0.0835	0	0.0844	1.4532	1.3125	1.4561	1.1907	1.0971	1.1922	0.0963	0	0.0989
κ		-4.6538	-4.6995		-6.1993	-6.2713		-1.2697	-1.3916		-0.4046	-0.4854		-8.5411	-8.6256
υ			0.0041			0.0064			0.0076			0.0047			-0.0081
United Kingdom III															
g	0.7187	0	0.7192	1.1289	0	1.1299	2.4126	0	2.4176	1.2694	0	1.2710	1.5397	0	1.5437
Q_N	0	-0.6543	0	0	-1.0242	0	0	-2.1660	0	0	-1.1506	0	0	-1.3940	0
L	0.6620	0.6586	0.6621	1.0402	1.0348	1.0402	0.4377	0.4264	0.4380	0.0722	0.0662	0.0723	1.4210	1.4137	1.4212
C/Y	-0.0044	0	-0.0044	-0.0068	0	-0.0069	-0.5602	-0.5458	-0.5605	-0.0927	-0.0850	-0.0928	-1.8008	-1.7918	-1.8011
Z/Y	0.0562	0	0.0567	0.0878	0	0.0888	1.4980	1.3125	1.5027	1.1963	1.0971	1.1979	0.1170	0	0.1208
κ		-4.6232	-4.6764		-6.1225	-6.2063		-2.6751	-2.8544		-0.4673	-0.5621		-9.8493	-9.9638
υ			0.0041			0.0064			0.0101			0.0046			-0.0093
United Kingdom IV															
g	0.7282	0	0.7289	1.1439	0	1.1453	3.7380	0	3.7513	1.3115	0	1.3138	2.1044	0	2.1131
Q_N	0	-0.6543	0	0	-1.0242	0	0	-3.2778	0	0	-1.1731	0	0	-1.8732	0
L	0.6638	0.6586	0.6639	1.0430	1.0348	1.0431	0.9563	0.9303	0.9573	0.0982	0.0889	0.0984	1.9239	1.9090	1.9246
C/Y	-0.0067	0	-0.0067	-0.0104	0	-0.0105	-1.2176	-1.1847	-1.2188	-0.1262	-0.1142	-0.1264	-2.4262	-2.4078	-2.4270
Z/Y	0.0640	0	0.0646	0.0998	0	0.1011	1.6284	1.3125	1.6404	1.2121	1.0971	1.2142	0.1771	0	0.1850
κ		-4.5487	-4.6208		-5.9339	-6.0476		-6.0855	-6.4576		-0.6176	-0.7488		-13.022	-13.232
υ			0.0042			0.0066			0.0165			0.0045			-0.0123

Notes: See Table 5.1 for a description of the different scenarios. All changes are percentage changes, except for κ and υ, which are defined as in Section 5.3.2.

Changes in labor supply are the largest for an increase in government expenditures, followed by lower taxes on labor income, capital income, and consumption. More generous tax incentives with respect to research effort lead to the smallest changes in the share of time endowment allocated to labor. In the TEG equilibrium, the long-run effects are smaller than the short-run effects, which is in line with the theoretical predictions of the model, although the differences are rather small.

The impact on the government budget is measured by κ, where in its calculation we use the actual transfer-to-output ratio rather than the ones implied by the model since the latter differ across the scenarios and may bias the results. Making tax incentives with respect to research effort more generous leads to the smallest impact on the long-run government budget balance, in terms of a lower transfer-to-output ratio. This fiscal policy is followed by the lower tax rates on capital income, consumption, and labor income. The largest impact on the budget balance of the government is caused by the increase in government expenditures.

Welfare effects are measured by υ. The largest welfare gain is obtained by lowering the tax rate on labor income, followed by a lower tax rate on capital income and consumption. More generous tax incentives for research effort lead to the smallest welfare gain. Increasing government expenditures lead to a loss in welfare, which can be explained by government expenditures being modeled as pure waste. A larger claim of the government on the private sector then means a larger part of private activity is crowded out.

For comparison, we normalize the effect such that all fiscal policies lead to an increase in the growth rate per capita of one percent for the PEG equilibrium and to a decrease in Q_N of one percent for the TEG equilibrium. The results are given in Table 5.3 and suggest that the least costly way, in terms of the impact on the government budget, to promote economic growth is by making tax incentives with respect to research effort more generous. This fiscal policy is followed by lower tax rates on capital income and labor income. Higher government expenditures and a lower tax rate on consumption are the most expensive policies to boost economic activity. The corresponding changes in labor supply follow a similar pattern.

Table 5.3: Effects of Fiscal Policies: Normalized

Instrument	Continental Europe				United Kingdom			
	TEG		PEG		TEG		PEG	
	κ	L	κ	L	κ	L	κ	L
τ_C	-4.4907	1.0065	-3.6047	0.8075	-7.0452	1.0066	-6.4732	0.9188
τ_L	-3.1486	1.0131	-2.5297	0.8075	-5.9444	1.0103	-5.4546	0.9188
τ_X	-1.0031	0.2395	-0.8341	0.1973	-1.2936	0.2058	-1.2281	0.1882
s_Z	-0.2742	0.0606	-0.2768	0.0599	-0.4268	0.0607	-0.4641	0.0600
ω_G	-4.4907	1.0166	-3.5686	0.8075	-7.0452	1.0150	-6.4199	0.9188

Notes: Continental Europe is the average of France, Germany, and Italy. The effects are percent changes and are the result of a change in fiscal instruments such that Q_N decreases with one percent in the TEG equilibrium and $g-n$ increases with one percent in the PEG equilibrium. The numbers are the average of all scenarios.

The above results hold for both economies and are robust across the different scenarios. To stimulate economic activity, more generous tax incentives with respect to research effort are almost three times as effective as lowering the tax rate on capital, which in turn is at least three times as effective as lowering the tax rate on labor income. An explanation of this result may be the relative size of the initial tax bases of the instruments. For example, the tax base of tax incentives with respect to research effort, which is the output share of research expenditures, is relatively small compared to the bases of the other instruments. A relatively small initial tax base causes smaller losses in revenues when tax rates are lowered. Of course, this effect has to be compared with the resulting efficiency gains of changes in the fiscal policy instruments, which may be independent of their corresponding initial tax bases.

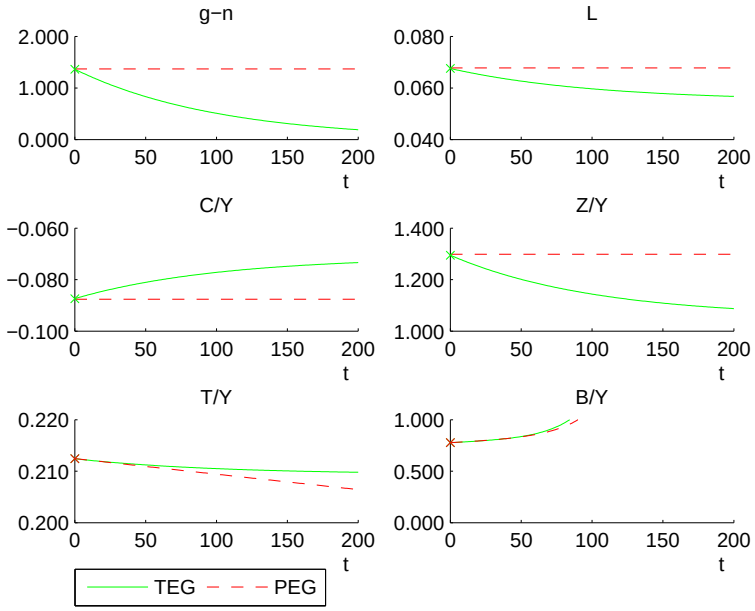
5.4.2.2. Non-distorting Financing Scheme with Debt

Under the previous financing scheme, the transfers to households are adjusted to ensure the intertemporal budget constraint of the government is satisfied. At the same time, the debt-to-output ratio is assumed to be constant. As an alternative finance scheme, we assume the path of transfers to households to be predetermined so that transfers cannot be lowered to improve the budget balance of the government. We do, however, allow for temporary changes in the debt-to-output ratio now. Figure 5.6 gives the impulse response functions of more generous tax incentives with respect to research effort for both economies under the second scenario. We choose this

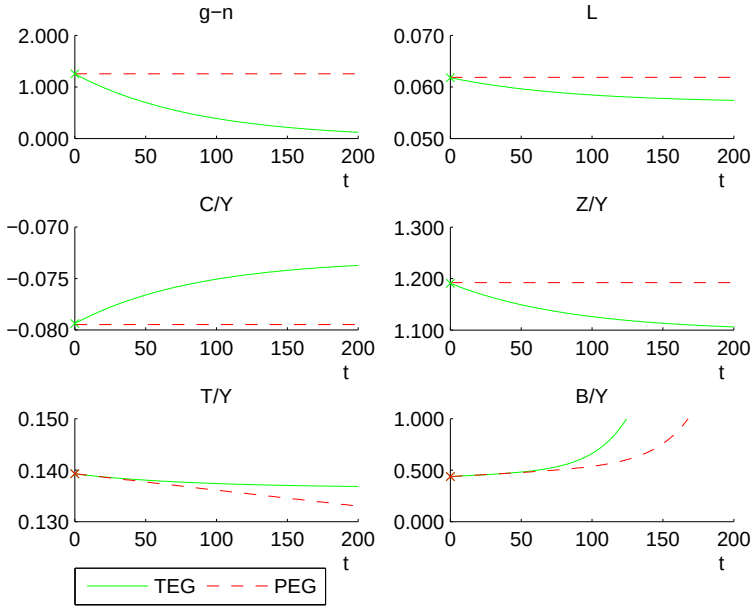
scenario because it has the highest κ, and the possibility of obtaining a dynamic Laffer effect is the largest of all scenarios.

Figure 5.6: Impulse Response Functions of Fiscal Policies

(a) Continental Europe II: $\Delta s_Z = 0.01$



(b) United Kingdom II: $\Delta s_Z = 0.01$



Notes: Impulse responses of an unexpected and permanent shock at time 0 for both the TEG equilibrium (solid line) and PEG equilibrium (dashed line). The vertical axes show ratios, and the horizontal axes show time in years. Based on scenario *II*.

For Continental Europe, the debt-to-output ratio increases over time (see Figure 5.6a), which means the resources that come available in the future, as a result of the predetermined path of transfers, are insufficient to cover the initial deterioration of the budget balance of the government and the temporary increase in government debt. The same result is obtained for the United Kingdom. None of the fiscal policies lead to a dynamic Laffer effect, which can be explained by the relatively large deterioration of the government budget balance in the short run compared to the resulting efficiency gains of these policies; see Van Oudheusden (2009).

5.4.2.3. Distorting Financing Scheme

As a final financing scheme, we consider the case where changes in the budget balance of the government, as a result of fiscal policies, are offset by adjusting expenditures or other distorting taxes. In addition, we assume constant output shares of lump-sum transfers and debt. The previous results already suggest what to expect. We know that adjusting government expenditures or the consumption tax are the most expensive way, in terms of their impact on the budget balance of the government, to promote economic activity; see Table 5.3. Thus, they should be the least expensive way, in terms of their impact on economic activity, to offset changes in the budget balance of the government. This expectation is confirmed in Table 5.4.

For tax incentives with respect to research effort, offsetting changes in the government budget balance with the consumption tax leads to an increase in the growth rate per capita that is on average 94 percent of the increase under the non-distorting finance scheme. Adjusting the tax rate on labor income or capital income are less efficient with percentages of around 92 and 65, respectively. When financing a lower tax rate on capital income by adjusting the consumption tax rate, the increase in the growth rate per capita is only 82 percent of the increase under the non-distorting finance scheme. In all cases, changes in the share of time endowment allocated to labor are relatively small. Adjustments of the consumption tax rate also lead to the largest gain in welfare.[33]

[33]Financing with government expenditures does lead to a higher gain in welfare, but this is the results of government expenditures being modeled as waste. Lower expenditures then imply that waste is lower and welfare is higher.

Table 5.4: Effects of Fiscal Policies: Alternative Financing Schemes

	non-distortionary			τ_X			τ_C			τ_L			ω_G		
	TEG		PEG	TEG		PEG	TEG		PEG	TEG		PEG	TEG		PEG
	$t=0$	$t=\infty$		$t=0$	$t=\infty$		$t=0$	$t=\infty$		$t=0$	$t=\infty$		$t=0$	$t=\infty$	
Continental Europe: $\Delta s_Z = 0.01$															
g	1.3633	0	1.3673	1.0007	0	0.9302	1.2951	0	1.2812	1.2633	0	1.2419	1.2953	0	1.2812
Q_N	0	-1.0971	0	0	-0.7981	0	0	-1.0428	0	0	-1.0174	0	0	-1.0428	0
L	0.0676	0.0550	0.0678	0.0054	-0.0056	-0.0081	0.0120	0	-0.0022	-0.0139	-0.0256	-0.0341	0.0120	0	-0.0022
C/Y	-0.0874	-0.0711	-0.0876	-0.0070	0.0072	0.0104	-0.0866	-0.0711	-0.0866	-0.0862	-0.0711	-0.0861	-0.0155	0	0.0028
Z/Y	1.2949	1.0537	1.2987	1.0674	0.8822	1.0240	1.2830	1.0537	1.2834	1.2775	1.0537	1.2764	1.2832	1.0537	1.2834
instrument					0.2015	0.2017		0.1898	0.1901		0.4122	0.4124		0.2281	0.2280
υ			0.0024			0.0013			0.0020			0.0018			0.0029
Continental Europe: $\Delta\tau_X = -0.01$															
g	2.3250	0	2.3350				1.9766	0	1.9575	1.8143	0	1.7851	1.9779	0	1.9575
Q_N	0	-1.8590	0				0	-1.5843	0	0	-1.4559	0	0	-1.5843	0
L	0.3427	0.3213	0.3431				0.0595	0.0413	0.0381	-0.0724	-0.0891	-0.1012	0.0595	0.0413	0.0381
C/Y	-0.4420	-0.4146	-0.4427				-0.4380	-0.4146	-0.4382	-0.4362	-0.4146	-0.4362	-0.0769	-0.0534	-0.0493
Z/Y	1.6565	1.2502	1.6660				1.5972	1.2502	1.5998	1.5693	1.2502	1.5695	1.5984	1.2502	1.5998
instrument								0.1933	0.1936		0.4147	0.4149		0.2264	0.2262
υ			0.0051						0.0033			0.0025			0.0072
United Kingdom: $\Delta s_Z = 0.01$															
g	1.2533	0	1.2548	0.8467	0	0.7940	1.1908	0	1.1805	1.1789	0	1.1665	1.1909	0	1.1805
Q_N	0	-1.1415	0	0	-0.7702	0	0	-1.0852	0	0	-1.0744	0	0	-1.0852	0
L	0.0618	0.0569	0.0619	-0.0040	-0.0080	-0.0136	0.0046	0	-0.0060	-0.0063	-0.0109	-0.0188	0.0046	0	-0.0060
C/Y	-0.0794	-0.0731	-0.0795	0.0052	0.0103	0.0175	-0.0791	-0.0731	-0.0791	-0.0790	-0.0731	-0.0790	-0.0059	0	0.0078
Z/Y	1.1907	1.0971	1.1922	0.9323	0.8658	0.8996	1.1862	1.0971	1.1866	1.1853	1.0971	1.1855	1.1862	1.0971	1.1866
instrument					0.2398	0.2401		0.1899	0.1900		0.2511	0.2512		0.2093	0.2092
υ			0.0047			0.0026			0.0043			0.0042			0.0051
United Kingdom: $\Delta\tau_X = -0.01$															
g	1.8995	0	1.9026				1.7025	0	1.6883	1.6650	0	1.6480	1.7028	0	1.6883
Q_N	0	-1.7206	0				0	-1.5448	0	0	-1.5112	0	0	-1.5448	0
L	0.2322	0.2249	0.2323				0.0524	0.0459	0.0373	0.0183	0.0118	0.0006	0.0524	0.0459	0.0373
C/Y	-0.2978	-0.2884	-0.2980				-0.2968	-0.2884	-0.2969	-0.2966	-0.2884	-0.2967	-0.0674	-0.0589	-0.0479
Z/Y	1.4532	1.3125	1.4561				1.4390	1.3125	1.4402	1.4363	1.3125	1.4372	1.4393	1.3125	1.4402
instrument								0.1917	0.1920		0.2524	0.2526		0.2083	0.2082
υ			0.0076						0.0064			0.0062			0.0089

Notes: All changes are percentage changes, except for υ, which is defined as in Section 5.3.2.

In general, making tax incentives with respect to research effort more generous is the least costly way to boost economic activity. If non-distorting finance options are excluded, then adjusting government expenditures and the consumption tax to finance this policy lead to the smallest loss in efficiency. The last result may be changed when giving government expenditures a more prominent role in the framework. In our framework, government expenditures are modeled as waste. Including them in the utility function in a separable way may be useful for welfare analysis, but it does not change the results; see Agell and Persson (2001) and Trabandt and Uhlig (2011). When included in a non-separable way, government expenditures affect the effective intertemporal elasticity of substitution (Agell and Persson, 2001; Van Oudheusden, 2009) and possibly transitional dynamics (Van Oudheusden, 2009).[34] The general findings, however, should remain valid.

5.5. Conclusions

Using a calibrated dynamic general equilibrium framework featuring endogenous growth through creative destruction, we analyze dynamic feedback effects of fiscal policies on the government budget balance for several European countries. Making tax incentives with respect to research effort more generous is the least costly way, in terms of the impact on the government budget, to boost economic activity. Moreover, this policy is almost three times as cost effective as the next best policy, which is a lower tax rate on capital income. A dynamic Laffer effect is never possible for any of the fiscal policies. If financing with non-distorting means is excluded, adjusting government expenditures and the consumption tax rate are the preferred policies to keep the long-run government budget balanced. Governments that face the challenge to set fiscal policies such that they result in sufficient revenues to deal with long-run budget challenges and promote economic growth at the same time could possibly benefit by taking into account the above findings.

[34]Transitional dynamics are influenced in the case where the PEG equilibrium is locally stable, which is not the case in our analysis. See Leeper and Yang (2008) for an additional discussion on including government expenditures in dynamic scoring analyses.

Future research could usefully focus on extending the framework with additional growth engines; for example, the inclusion of human capital accumulation or a more elaborate process of the investment and depreciation of physical capital. However, explicitly modeling intermediate good specific capital stocks may change research effort incentives by introducing an additional element of competition. Firms then not only compete on basis of their relative quality but also have to take into account the stock of machines of competitors. This may create an additional role for government policies in the form of directed R&D subsidies or sector specific depreciation allowances. Including public R&D expenditures in addition to private R&D expenditures may be another avenue for future research.

Appendix 5.A

This appendix describes the derivations of equations (5.8), (5.9), and (5.15). Moreover, it provides the data, and corresponding sources, we use in the calibration of the model.

5.A.1 Derivation of Equations

Derivation of (5.8)

The derivation of equation (5.8) is as follows. Assume that the leading-edge quality at time t and time $t + \Delta t$ is given by

$$Q(t) = Q(0)e^{\frac{S(t)}{v-1}},$$
$$Q(t + \Delta t) = Q(0)e^{\frac{S(t+\Delta t)}{v-1}},$$

so that

$$\frac{\ln Q(t + \Delta t) - \ln Q(t)}{\Delta t} = \frac{S(t + \Delta t) - S(t)}{\Delta t(v - 1)}.$$

Taking the limit as $\Delta t \to 0$ then gives

$$\frac{\dot{Q}(t)}{Q(t)} = \frac{\dot{S}(t)}{v - 1} = \frac{z(t)}{v - 1},$$

where $v > 1$, $Q(0) > 0$, $S(t)$ is the total number of innovations between time 0 and time t, and $\dot{S}(t) = z(t)$ is the aggregate flow of innovations.

Derivation of (5.9)

In deriving equation (5.9), we follow Aghion and Howitt (1998, p.115). We define $\Theta(t) \equiv F(\bar{Q}, t)$ as the mass of intermediate goods that are produced with quality lower than $\bar{Q} > 0$, where $F(\cdot, t)$ is the cumulative distribution function of absolute qualities at time t, and $\bar{Q}$ is the leading-edge quality at time $t_0 \geq 0$. This means that $Q(t_0) = \bar{Q}$ and $\Theta(t_0) = 1$. As a result of innovations, intermediate goods that are being produced with qualities lower than $\bar{Q}$ jump to the leading-edge quality so that $\Theta(t)$ decreases

over time. More specifically, this process is given by $\dot{\Theta}(t) = -\Theta(t)z(t) \ \forall \ t \geq t_0$, which says that the decline in $\Theta(t)$ equals the number of intermediate goods with quality lower than $\bar{Q}$ times the aggregate flow rate of new innovations $z(t)$. From equation (5.8), we know that in general the leading-edge quality evolves over time according to $\dot{Q}(t) = z(t)(1-v)^{-1}Q(t)$. We solve these two differential equations to get

$$\Theta(t) = e^{-\int_{t_0}^{t} z(t')dt'},$$
$$Q(t) = \bar{Q}\left(e^{\int_{t_0}^{t} z(t')dt'}\right)^{\frac{1}{v-1}},$$

and combining the solutions gives

$$\Theta(t) = \left(\frac{\bar{Q}}{Q(t)}\right)^{v-1} = q^{v-1},$$

with $0 \leq q \leq 1$ and $q \equiv \bar{Q}/Q(t)$. Since $\Theta(t)$ is the mass of intermediate goods that are produced with quality lower than $qQ(t)$ at time t, the distribution function of quality $Q_i(t)$ with relative quality q can be given by $J(q) \equiv q^{v-1}$. This means that the distribution function of any quality $Q_i(t)$ is independent of the leading-edge quality. Moreover, intermediate goods can be classified according to their relative qualities so that the sum of qualities at any time is given by

$$\int_0^1 Q_i(t)^\theta di = Q(t)^\theta \int_0^1 q^\theta \frac{\partial J(q)}{\partial q} dq = \frac{v-1}{v-1+\theta} Q(t)^\theta.$$

Derivation of (5.15)

The derivation of equation (5.15) is standard though quite tedious. Basically, we combine the intratemporal optimality condition between consumption and leisure, the intertemporal optimality condition that says the return on consumption should equal the return on investment, and the aggregate resource constraint.

The intratemporal optimality condition between leisure and per capita consumption is obtained by dividing equation (5.12b) by equation (5.12a) and says that at each point in time the marginal rate of substitution between leisure and per capita

consumption should equal its relative price:

$$\begin{aligned}\frac{\epsilon_L}{\epsilon_C}\frac{c(t)}{1-L(t)} &= \frac{1-\tau_L}{1+\tau_C}w(t)\\ &= \frac{1-\tau_L}{1+\tau_C}\frac{1-\alpha}{\alpha}\left(\frac{\epsilon_\beta}{\epsilon_\beta-1}\frac{\psi}{1-\tau_X}\right)^{\frac{\alpha}{\alpha-1}}\left(\frac{v-1}{v-1+\theta}Q(t)^\theta\right)^{\frac{\alpha}{(\alpha-1)(1-\epsilon_\beta)}},\end{aligned}$$

where we rewrite $w(t)$ by using $P(t) \equiv \left(\int_0^1 p_i(t|Q_i(t))^{1-\epsilon_\beta}Q_i(t)^{\theta\epsilon_\beta}di\right)^{\frac{1}{1-\epsilon_\beta}}$ and equations (5.2), (5.3), (5.5), and (5.8). Taking the logarithm and subsequently the time derivative of this intratemporal optimality condition and rearranging terms gives

$$\frac{\dot{c}(t)}{c(t)} = \frac{\theta\alpha}{(\alpha-1)(1-\epsilon_\beta)}\frac{\dot{Q}(t)}{Q(t)} - \frac{\dot{L}(t)}{1-L(t)}. \tag{5.15a}$$

The return on consumption is given by

$$\rho - \frac{\dot{\lambda}(t)}{\lambda(t)} = \rho + (1-(1-\sigma)\epsilon_C)\frac{\dot{c}(t)}{c(t)} + (1-\sigma)\epsilon_L\frac{\dot{L}(t)}{1-L(t)}, \tag{5.15b}$$

where the expression for $\dot{\lambda}(t)/\lambda(t)$ is obtained by taking the logarithm and subsequently the time derivative of equation (5.12a). The return on investment is given by

$$r(t) = \frac{\eta}{\epsilon_\beta}\frac{1-\tau_X}{1-s_Z}\left(\frac{\epsilon_\beta}{\epsilon_\beta-1}\frac{\psi}{1-\tau_X}\right)^{\frac{\alpha}{\alpha-1}}\left(\frac{v-1}{v-1+\theta}\right)^{\frac{1}{1-\epsilon_\beta}\left(\epsilon_\beta-\frac{1}{1-\alpha}\right)}Q_N(t)L(t) - (v-1)\frac{\dot{Q}(t)}{Q(t)}, \tag{5.15c}$$

where we use equations (5.6)–(5.9), and $z_i(t) = z(t)$ since the return on research effort is the same for all intermediate goods and the total number of intermediate goods is normalized to unity. Moreover,

$$Q_N(t) \equiv Q(t)^{\frac{\theta\alpha}{(\alpha-1)(1-\epsilon_\beta)}-\phi}N(t). \tag{5.15d}$$

The intertemporal optimality condition is given by equation (5.12c), rearranging gives

$$\rho - \frac{\dot{\lambda}}{\lambda} = r(t), \tag{5.15e}$$

which says that the return on consumption should equal the return on investment.

The derivation of the condition corresponding to the aggregate resource constraint is as follows. First, we multiply the per capita budget constraint (5.11b) by $N(t)$, add up the resource constraint of the government (5.14). Now, we use that $A(t) \equiv \int_0^1 V_i(t|Q_i(t))di$ since we have a closed economy. We further use that perfect competition in the research sector implies $z_i(t|Q_i(t))V_i(t|Q_i(t) = (1-s_Z)Z_i(t|Q_i(t))$, perfect competition in the final good sector implies $\int_0^1 \pi_i(t|Q_i(t))di + w(t)H(t) = Y(t) - \int_0^1 \psi Q_i(t)^\theta x_i(t|Q_i(t)) = Y(t) - X(t)$, and $G(t) = \omega_G Y(t)$ so that the aggregate resource constraint is given by $Y(t) = C(t) + G(t) + X(t) + Z(t)$. We know that

$$
\begin{aligned}
Y(t) &= \left(\frac{v-1}{v-1+\theta}\right)^{\frac{\alpha}{(\alpha-1)(1-\epsilon_\beta)}} \left(\frac{\epsilon_\beta}{\epsilon_\beta - 1}\frac{\psi}{1-\tau_X}\right)^{\frac{\alpha}{\alpha-1}} Q_N(t)Q(t)^\phi \frac{L(t)}{\alpha}, \\
C(t) &= \left(\frac{v-1}{v-1+\theta}\right)^{\frac{\alpha}{(\alpha-1)(1-\epsilon_\beta)}} \left(\frac{\epsilon_\beta}{\epsilon_\beta - 1}\frac{\psi}{1-\tau_X}\right)^{\frac{\alpha}{\alpha-1}} Q_N(t)Q(t)^\phi \frac{\epsilon_C}{\epsilon_L}\frac{1-\tau_L}{1+\tau_C}\frac{1-\alpha}{\alpha}(1-L(t)), \\
G(t) &= \left(\frac{v-1}{v-1+\theta}\right)^{\frac{\alpha}{(\alpha-1)(1-\epsilon_\beta)}} \left(\frac{\epsilon_\beta}{\epsilon_\beta - 1}\frac{\psi}{1-\tau_X}\right)^{\frac{\alpha}{\alpha-1}} Q_N(t)Q(t)^\phi \frac{L(t)}{\alpha}\omega_G, \\
X(t) &= \left(\frac{v-1}{v-1+\theta}\right)^{\frac{\alpha}{(\alpha-1)(1-\epsilon_\beta)}} \left(\frac{\epsilon_\beta}{\epsilon_\beta - 1}\frac{\psi}{1-\tau_X}\right)^{\frac{\alpha}{\alpha-1}} Q_N(t)Q(t)^\phi \frac{\epsilon_\beta - 1}{\epsilon_\beta}L(t), \\
Z(t) &= (v-1)\frac{\dot{Q}(t)}{Q(t)}\eta^{-1}Q(t)^\phi,
\end{aligned}
$$

where we used $P(t) = \left(\int_0^1 p_i(t|Q_i(t))^{1-\epsilon_\beta} Q_i(t)^{\theta\epsilon_\beta} di\right)^{\frac{1}{1-\epsilon_\beta}}$, $Z(t) = z(t)\eta^{-1}Q(t)^\phi$, and equations (5.1), (5.2), (5.3), (5.8), (5.9), (5.12a), and (5.12b). The aggregate resource constraint can then be written as

$$
\frac{\dot{Q}(t)}{Q(t)} = \frac{\xi}{\alpha}Q_N(t)L(t)\left(1 - \omega_G - \alpha(1-\tau_X)\frac{\epsilon_\beta - 1}{\epsilon_\beta} - \frac{\epsilon_C}{\epsilon_L}\frac{1-\tau_L}{1+\tau_C}(1-\alpha)\frac{1-L(t)}{L(t)}\right), \tag{5.15f}
$$

with $\xi \equiv \frac{\eta}{v-1}\left(\frac{v-1}{v-1+\theta}\right)^{\frac{\alpha}{(\alpha-1)(1-\epsilon_\beta)}}\left(\frac{\epsilon_\beta}{\epsilon_\beta-1}\frac{\psi}{1-\tau_X}\right)^{\frac{\alpha}{\alpha-1}}$. Combining equation (5.15a)–(5.15f) and rearranging terms gives equation (5.15).

5.A.2 Data

The data are on the next pages.

Table A.1: Calibration Data

	Economy	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Average
L	France	1651	1655	1649	1637	1630	1591	1578	1537	1532	1561	1557	1536	1593
	Germany	1534	1518	1509	1503	1492	1473	1458	1445	1439	1442	1434	1430	1473
	Italy	1859	1873	1863	1880	1876	1861	1843	1831	1826	1826	1819	1815	1848
	Continental Europe	1681	1682	1673	1673	1666	1642	1627	1604	1599	1610	1603	1593	1638
	United Kingdom	1631	1630	1630	1624	1613	1602	1605	1587	1570	1565	1569	1564	1599
n	France	0.0088	0.0038	0.0044	0.0151	0.0200	0.0265	0.0176	0.0062	0.0013	0.0011	0.0055	0.0098	0.0100
	Germany	0.0023	-0.0027	-0.0009	0.0119	0.0134	0.0186	0.0044	-0.0056	-0.0095	0.0040	-0.0012	0.0062	0.0034
	Italy	-0.0020	0.0057	0.0031	0.0098	0.0108	0.0192	0.0200	0.0170	0.0149	0.0044	0.0057	0.0194	0.0107
	Continental Europe	0.0030	0.0022	0.0022	0.0123	0.0147	0.0214	0.0140	0.0058	0.0022	0.0031	0.0034	0.0118	0.0080
	United Kingdom	0.0122	0.0093	0.0178	0.0102	0.0138	0.0116	0.0082	0.0076	0.0095	0.0106	0.0101	0.0087	0.0108
$g - n$	France	0.0156	0.0122	0.0195	0.0216	0.0131	0.0102	-0.0024	0.0017	0.0099	0.0232	0.0129	0.0116	0.0124
	Germany	0.0165	0.0126	0.0188	0.0082	0.0065	0.0130	0.0079	0.0056	0.0073	0.0080	0.0087	0.0270	0.0117
	Italy	0.0282	0.0075	0.0142	0.0047	0.0091	0.0183	0.0004	-0.0081	-0.0064	0.0115	0.0050	0.0048	0.0074
	Continental Europe	0.0201	0.0108	0.0175	0.0115	0.0096	0.0138	0.0020	-0.0003	0.0036	0.0143	0.0088	0.0145	0.0105
	United Kingdom	0.0179	0.0191	0.0148	0.0253	0.0203	0.0268	0.0161	0.0132	0.0182	0.0185	0.0114	0.0188	0.0184
$1 - \alpha$	France	0.6726	0.6744	0.6686	0.6609	0.6667	0.6615	0.6601	0.6632	0.6622	0.6618	0.6619	0.6588	0.6644
	Germany	0.6633	0.6602	0.6522	0.6501	0.6549	0.6633	0.6594	0.6546	0.6541	0.6448	0.6358	0.6246	0.6514
	Italy	0.6324	0.6315	0.6379	0.6289	0.6261	0.6167	0.6139	0.6157	0.6190	0.6167	0.6231	0.6298	0.6243
	Continental Europe	0.6561	0.6554	0.6529	0.6466	0.6492	0.6472	0.6445	0.6445	0.6451	0.6411	0.6403	0.6377	0.6467
	United Kingdom	0.7125	0.6929	0.6914	0.7021	0.7068	0.7193	0.7254	0.7152	0.7130	0.7087	0.7069	0.7054	0.7083
C	France	0.5661	0.5692	0.5584	0.5564	0.5542	0.5573	0.5599	0.5593	0.5644	0.5662	0.5686	0.5680	0.5623
as share of Y	Germany	0.5773	0.5818	0.5825	0.5788	0.5840	0.5887	0.5956	0.5895	0.5937	0.5894	0.5911	0.5836	0.5863
	Italy	0.5841	0.5791	0.5847	0.5919	0.5985	0.5992	0.5908	0.5870	0.5909	0.5863	0.5904	0.5907	0.5895
	Continental Europe	0.5758	0.5767	0.5752	0.5757	0.5789	0.5817	0.5821	0.5786	0.5830	0.5806	0.5834	0.5808	0.5794
	United Kingdom	0.6346	0.6401	0.6410	0.6461	0.6509	0.6555	0.6585	0.6577	0.6513	0.6476	0.6499	0.6414	0.6479
$X + Z$	France	0.1493	0.1473	0.1455	0.1508	0.1584	0.1639	0.1647	0.1584	0.1577	0.1619	0.1665	0.1746	0.1582
as share of Y	Germany	0.1972	0.1925	0.1916	0.1928	0.1942	0.1967	0.1827	0.1666	0.1631	0.1607	0.1605	0.1680	0.1806
	Italy	0.1701	0.1679	0.1676	0.1698	0.1725	0.1799	0.1795	0.1918	0.1790	0.1811	0.1837	0.1875	0.1775
	Continental Europe	0.1722	0.1692	0.1683	0.1711	0.1750	0.1802	0.1756	0.1722	0.1666	0.1679	0.1703	0.1767	0.1721
	United Kingdom	0.1456	0.1516	0.1546	0.1647	0.1612	0.1593	0.1532	0.1524	0.1479	0.1489	0.1602	0.1529	0.1544

(*Continued*)

Table A.1: Calibration Data (continued)

	Economy	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Average
τ_C	France	0.2154	0.2210	0.2222	0.2195	0.2207	0.2089	0.2028	0.2033	0.1996	0.2011	0.2005	0.1987	0.2095
	Germany	0.1883	0.1831	0.1806	0.1832	0.1903	0.1890	0.1851	0.1854	0.1864	0.1821	0.1808	0.1827	0.1847
	Italy	0.1741	0.1709	0.1735	0.1780	0.1799	0.1791	0.1731	0.1712	0.1655	0.1685	0.1671	0.1733	0.1728
	Continental Europe	0.1926	0.1917	0.1921	0.1936	0.1970	0.1924	0.1870	0.1866	0.1839	0.1839	0.1828	0.1849	0.1890
	United Kingdom	0.1965	0.1956	0.1949	0.1920	0.1940	0.1894	0.1860	0.1849	0.1875	0.1868	0.1811	0.1799	0.1890
τ_L	France	0.4117	0.4143	0.4174	0.4220	0.4242	0.4199	0.4167	0.4119	0.4150	0.4145	0.4192	0.4188	0.4171
	Germany	0.3944	0.3961	0.4057	0.4061	0.4037	0.4074	0.4050	0.4039	0.4039	0.3918	0.3883	0.3894	0.3997
	Italy	0.3819	0.4185	0.4347	0.4328	0.4268	0.4216	0.4213	0.4201	0.4187	0.4164	0.4134	0.4110	0.4181
	Continental Europe	0.3960	0.4096	0.4193	0.4203	0.4182	0.4163	0.4143	0.4120	0.4125	0.4076	0.4070	0.4064	0.4116
	United Kingdom	0.2575	0.2484	0.2438	0.2504	0.2511	0.2533	0.2501	0.2410	0.2431	0.2491	0.2563	0.2602	0.2504
τ_X	France	0.1572	0.1753	0.1793	0.1811	0.2019	0.2079	0.2146	0.1984	0.1867	0.1929	0.1979	0.2206	0.1928
	Germany	0.1721	0.2005	0.1954	0.2072	0.2348	0.2378	0.1739	0.1610	0.1606	0.1648	0.1761	0.1972	0.1901
	Italy	0.1803	0.1938	0.2188	0.2001	0.2237	0.2245	0.2238	0.2121	0.2412	0.2183	0.2174	0.2548	0.2174
	Continental Europe	0.1699	0.1899	0.1978	0.1961	0.2202	0.2234	0.2041	0.1905	0.1962	0.1920	0.1971	0.2242	0.2001
	United Kingdom	0.2057	0.2074	0.2254	0.2415	0.2566	0.2675	0.2767	0.2404	0.2107	0.2207	0.2414	0.2630	0.2381
τ_C revenues	France	0.1205	0.1242	0.1228	0.1209	0.1213	0.1157	0.1126	0.1126	0.1114	0.1124	0.1124	0.1113	0.1165
as share of Y	Germany	0.1032	0.1015	0.1002	0.1009	0.1053	0.1054	0.1046	0.1036	0.1047	0.1017	0.1013	0.1013	0.1028
	Italy	0.1038	0.1008	0.1034	0.1072	0.1095	0.1094	0.1040	0.1019	0.0990	0.1001	0.0997	0.1036	0.1035
	Continental Europe	0.1092	0.1088	0.1088	0.1097	0.1120	0.1101	0.1070	0.1061	0.1050	0.1047	0.1045	0.1054	0.1076
	United Kingdom	0.1201	0.1205	0.1201	0.1189	0.1205	0.1182	0.1162	0.1152	0.1156	0.1146	0.1115	0.1093	0.1167
τ_L revenues	France	0.2271	0.2291	0.2289	0.2275	0.2315	0.2297	0.2288	0.2275	0.2292	0.2285	0.2306	0.2290	0.2290
as share of Y	Germany	0.2403	0.2432	0.2456	0.2437	0.2424	0.2452	0.2422	0.2415	0.2408	0.2309	0.2260	0.2212	0.2386
	Italy	0.1825	0.1991	0.2085	0.2078	0.2036	0.1988	0.2019	0.2022	0.2033	0.2011	0.2040	0.2048	0.2015
	Continental Europe	0.2166	0.2238	0.2277	0.2263	0.2258	0.2246	0.2243	0.2237	0.2244	0.2202	0.2202	0.2183	0.2230
	United Kingdom	0.1372	0.1299	0.1278	0.1344	0.1357	0.1397	0.1398	0.1334	0.1333	0.1356	0.1402	0.1408	0.1357
τ_X revenues	France	0.0401	0.0438	0.0455	0.0472	0.0513	0.0535	0.0554	0.0494	0.0459	0.0472	0.0477	0.0542	0.0484
as share of Y	Germany	0.0429	0.0500	0.0501	0.0531	0.0576	0.0570	0.0420	0.0398	0.0405	0.0440	0.0494	0.0583	0.0487
	Italy	0.0754	0.0823	0.0875	0.0761	0.0820	0.0832	0.0841	0.0762	0.0848	0.0767	0.0738	0.0842	0.0805
	Continental Europe	0.0528	0.0587	0.0610	0.0588	0.0637	0.0646	0.0605	0.0551	0.0571	0.0560	0.0570	0.0655	0.0592
	United Kingdom	0.0530	0.0566	0.0630	0.0666	0.0649	0.0654	0.0661	0.0583	0.0559	0.0584	0.0647	0.0720	0.0621

(*Continued*)

Table A.1: Calibration Data (continued)

	Economy	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Average
τ_C revenues	France	0.2822	0.2828	0.2782	0.2748	0.2702	0.2621	0.2570	0.2612	0.2596	0.2602	0.2576	0.2535	0.2666
as share of total	Germany	0.2594	0.2495	0.2463	0.2467	0.2525	0.2517	0.2616	0.2622	0.2640	0.2624	0.2614	0.2587	0.2564
	Italy	0.2591	0.2412	0.2364	0.2525	0.2577	0.2619	0.2508	0.2493	0.2395	0.2466	0.2468	0.2466	0.2490
	Continental Europe	0.2669	0.2578	0.2536	0.2580	0.2601	0.2586	0.2565	0.2576	0.2544	0.2564	0.2553	0.2529	0.2573
	United Kingdom	0.3466	0.3505	0.3447	0.3314	0.3331	0.3221	0.3187	0.3298	0.3334	0.3261	0.3095	0.2971	0.3286
τ_L revenues	France	0.5318	0.5217	0.5188	0.5172	0.5156	0.5205	0.5225	0.5276	0.5342	0.5290	0.5285	0.5213	0.5241
as share of total	Germany	0.6040	0.5980	0.6038	0.5960	0.5810	0.5857	0.6058	0.6108	0.6072	0.5961	0.5831	0.5647	0.5947
	Italy	0.4554	0.4760	0.4767	0.4895	0.4793	0.4760	0.4868	0.4947	0.4920	0.4956	0.5050	0.4876	0.4846
	Continental Europe	0.5304	0.5319	0.5331	0.5343	0.5253	0.5274	0.5384	0.5444	0.5445	0.5402	0.5388	0.5245	0.5344
	United Kingdom	0.3958	0.3779	0.3667	0.3745	0.3749	0.3804	0.3837	0.3818	0.3846	0.3860	0.3894	0.3827	0.3815
τ_X revenues	France	0.0938	0.0998	0.1032	0.1074	0.1142	0.1213	0.1266	0.1145	0.1070	0.1093	0.1092	0.1234	0.1108
as share of total	Germany	0.1078	0.1229	0.1232	0.1298	0.1382	0.1362	0.1051	0.1006	0.1021	0.1136	0.1274	0.1487	0.1213
	Italy	0.1881	0.1969	0.2000	0.1794	0.1931	0.1993	0.2028	0.1864	0.2053	0.1890	0.1827	0.2004	0.1936
	Continental Europe	0.1299	0.1398	0.1421	0.1388	0.1485	0.1523	0.1448	0.1339	0.1381	0.1373	0.1398	0.1575	0.1419
	United Kingdom	0.1530	0.1646	0.1807	0.1854	0.1795	0.1782	0.1813	0.1670	0.1613	0.1661	0.1795	0.1955	0.1743
s_Z	France					0.0850	0.0850				0.1340		0.1890	0.1233
	Germany					-0.0410	-0.0410				-0.0240		-0.0300	-0.0340
	Italy					-0.0270	-0.0270				0.2120		-0.0230	0.0338
	Continental Europe					0.0057	0.0057				0.1073		0.0453	0.0410
	United Kingdom					0.0560	0.0560				0.1010		0.1010	0.0785
Z	France												0.0459	0.0459
as share of Y	Germany												0.0431	0.0431
	Italy												0.0283	0.0283
	Continental Europe												0.0391	0.0391
	United Kingdom												0.0432	0.0432
B	France	0.5548	0.5800	0.5928	0.5943	0.5881	0.5733	0.5688	0.5882	0.6291	0.6487	0.6636	0.6366	0.6015
as share of Y	Germany	0.5560	0.5843	0.5966	0.6032	0.6090	0.5974	0.5883	0.6044	0.6394	0.6576	0.6799	0.6755	0.6160
	Italy	1.2155	1.2089	1.1806	1.1494	1.1370	1.0917	1.0879	1.0569	1.0442	1.0390	1.0594	1.0665	1.1114
	Continental Europe	0.7754	0.7911	0.7900	0.7823	0.7780	0.7542	0.7483	0.7498	0.7709	0.7818	0.8009	0.7929	0.7763
	United Kingdom	0.5123	0.5130	0.4978	0.4666	0.4368	0.4102	0.3773	0.3746	0.3904	0.4087	0.4251	0.4345	0.4373

(*Continued*)

Table A.1: Calibration Data (continued)

	Economy	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Average
G_c	France	0.2369	0.2392	0.2387	0.2310	0.2315	0.2290	0.2279	0.2339	0.2373	0.2372	0.2367	0.2337	0.2344
as share of Y	Germany	0.1957	0.1981	0.1939	0.1915	0.1925	0.1900	0.1894	0.1921	0.1926	0.1881	0.1871	0.1828	0.1912
	Italy	0.1796	0.1826	0.1831	0.1811	0.1823	0.1845	0.1897	0.1921	0.1969	0.1985	0.2034	0.2015	0.1896
	Continental Europe	0.2041	0.2066	0.2053	0.2012	0.2021	0.2012	0.2023	0.2060	0.2089	0.2079	0.2091	0.2060	0.2051
	United Kingdom	0.1951	0.1903	0.1815	0.1780	0.1827	0.1863	0.1904	0.1976	0.2043	0.2087	0.2138	0.2147	0.1953
G_p	France	0.0318	0.0316	0.0291	0.0283	0.0293	0.0308	0.0301	0.0293	0.0307	0.0311	0.0330	0.0320	0.0306
as share of Y	Germany	0.0218	0.0206	0.0184	0.0181	0.0187	0.0178	0.0174	0.0168	0.0156	0.0143	0.0135	0.0139	0.0172
	Italy	0.0206	0.0215	0.0215	0.0232	0.0238	0.0233	0.0237	0.0173	0.0245	0.0240	0.0236	0.0234	0.0225
	Continental Europe	0.0247	0.0246	0.0230	0.0232	0.0240	0.0240	0.0237	0.0211	0.0236	0.0231	0.0234	0.0231	0.0235
	United Kingdom	0.0199	0.0152	0.0120	0.0127	0.0129	0.0119	0.0149	0.0155	0.0159	0.0177	0.0071	0.0181	0.0145
T	France	0.1793	0.1802	0.1808	0.1771	0.1765	0.1713	0.1705	0.1735	0.1753	0.1758	0.1766	0.1763	0.1761
as share of Y	Germany	0.1761	0.1883	0.1885	0.1860	0.1862	0.1841	0.1859	0.1946	0.1976	0.1938	0.1916	0.1834	0.1880
	Italy	0.1629	0.1650	0.1695	0.1667	0.1686	0.1641	0.1620	0.1653	0.1681	0.1687	0.1695	0.1698	0.1667
	Continental Europe	0.1728	0.1778	0.1796	0.1766	0.1771	0.1732	0.1728	0.1778	0.1803	0.1794	0.1793	0.1765	0.1769
	United Kingdom	0.1504	0.1455	0.1407	0.1340	0.1282	0.1259	0.1289	0.1284	0.1281	0.1284	0.1287	0.1258	0.1327
$r_B B$	France	0.0347	0.0359	0.0347	0.0334	0.0302	0.0292	0.0305	0.0296	0.0283	0.0278	0.0267	0.0258	0.0306
as share of Y	Germany	0.0349	0.0348	0.0338	0.0336	0.0314	0.0315	0.0305	0.0292	0.0297	0.0282	0.0279	0.0282	0.0312
	Italy	0.1159	0.1152	0.0929	0.0818	0.0664	0.0637	0.0633	0.0567	0.0517	0.0480	0.0470	0.0463	0.0707
	Continental Europe	0.0618	0.0620	0.0538	0.0496	0.0427	0.0415	0.0414	0.0385	0.0366	0.0346	0.0339	0.0335	0.0442
	United Kingdom	0.0357	0.0357	0.0356	0.0347	0.0283	0.0271	0.0233	0.0200	0.0198	0.0196	0.0210	0.0206	0.0268
$G + T + r_B B$	France	0.4826	0.4870	0.4834	0.4697	0.4676	0.4603	0.4590	0.4662	0.4716	0.4718	0.4731	0.4679	0.4717
as share of Y	Germany	0.4287	0.4418	0.4346	0.4291	0.4287	0.4235	0.4232	0.4328	0.4355	0.4245	0.4201	0.4083	0.4276
	Italy	0.4789	0.4843	0.4671	0.4528	0.4411	0.4355	0.4387	0.4314	0.4413	0.4391	0.4435	0.4410	0.4496
	Continental Europe	0.4634	0.4710	0.4617	0.4505	0.4458	0.4398	0.4403	0.4434	0.4495	0.4451	0.4456	0.4391	0.4496
	United Kingdom	0.4011	0.3866	0.3698	0.3594	0.3521	0.3513	0.3575	0.3614	0.3680	0.3744	0.3706	0.3791	0.3693
Expenditures	France	0.4966	0.5028	0.5002	0.4882	0.4845	0.4771	0.4774	0.4883	0.4937	0.4920	0.4916	0.4866	0.4899
as share of Y	Germany	0.4469	0.4607	0.4537	0.4491	0.4493	0.4443	0.4423	0.4488	0.4533	0.4420	0.4401	0.4267	0.4464
	Italy	0.4802	0.4876	0.4686	0.4547	0.4425	0.4359	0.4385	0.4376	0.4399	0.4379	0.4405	0.4370	0.4501
	Continental Europe	0.4745	0.4837	0.4742	0.4640	0.4588	0.4524	0.4527	0.4582	0.4623	0.4573	0.4574	0.4501	0.4621
	United Kingdom	0.4072	0.3978	0.3861	0.3762	0.3703	0.3732	0.3792	0.3882	0.3956	0.4037	0.4140	0.4131	0.3921

Notes: Continental Europe is the average of France, Germany, and Italy. The exact definitions of the data are used for the calibration are given in Table A.2.

Table A.2: Data Sources

Variable	Source	Description
L	TED	Total annual hours worked
	AMECO: NETD	Employment, persons: all domestic industries
n	AMECO: NETD	Employment, persons: all domestic industries
$g-n$	AMECO: RVGDE	Gross domestic product at 2000 market prices per person employed
$1-\alpha$	AMECO: ALCD2	Adjusted wage share of total economy as percentage of GDP at current factor cost
Y	AMECO: UVGD	Gross domestic product at current market prices
C	AMECO: UCPH	Private final consumption expenditure at current prices
$X+Z$	AMECO: UIGP	Gross fixed capital formation at current prices: private sector
G_c	AMECO: UCTG	Final consumption expenditure of general government at current prices
G_p	AMECO: UIGG	Gross fixed capital formation at current prices: general government
T	AMECO: UYTGH	Social benefits other than social transfers in kind: general government
B	AMECO: UDGG	General government consolidated gross debt: Excessive deficit procedure
$r_B B$	AMECO: UUCG	Total current expenditure: general government
	AMECO: UUCGI	Total current expenditure excluding interest: general government
τ_C	TTEU: ITR C	Implicit tax rates in percentage - Consumption
τ_L	TTEU: ITR L	Implicit tax rates in percentage - Labour
τ_X	TTEU: ITR KI	Implicit tax rates in percentage - Capital and business income
revenues: τ_C	TTEU: C.1_G	Taxes on Consumption as percentage of GDP - Total
revenues: τ_L	TTEU: C.2_G	Taxes on Labour as percentage of GDP - Total
revenues: τ_X	TTEU: C.3.1_G	Taxes on Capital as percentage of GDP - Capital and business income
revenues: τ_C	TTEU: C.1_T	Taxes on Consumption as percentage of Total Taxation - Total
revenues: τ_L	TTEU: C.2_T	Taxes on Labour as percentage of Total Taxation - Total
revenues: τ_X	TTEU: C.3.1_T	Taxes on Capital as percentage of Total Taxation - Capital and business income
Z	MIANP: Chapter 1	Software, databases, R&D, and other intellectual property rights as percentage of GDP
s_Z	STIS: A12.1/C.3.1/2.37	One minus B-index: 2005/2007/2009

Notes: Data sources are
TED: http://www.conference-board.org/data/economydatabase/
AMECO: http://ec.europa.eu/economy_finance/db_indicators/ameco/index_en.htm
TTEU: http://ec.europa.eu/taxation_customs/taxation/gen_info/economic_analysis/tax_structures/index_en.htm
MIANP: Measuring Innovation: A New Perspective - OECD 2010 - ISBN 9789264059467
STIS: http://www.oecd-ilibrary.org/science-and-technology/oecd-science-technology-and-industry-scoreboard-2009_sti_scoreboard-2009-en

Bibliography

Acemoglu, D. (2009). *Introduction to modern economic growth*. Princeton, NJ: Princeton University Press.

Agell, J. and M. Persson (2001). On the analytics of the dynamic Laffer curve. *Journal of Monetary Economics 48*, 397–414.

Aghion, P. and P. Howitt (1992). A model of growth through creative destruction. *Econometrica 60*, 323–351.

Aghion, P. and P. Howitt (1998). *Endogenous growth theory*. Cambridge, MA: MIT Press.

Alesina, A. and E. L. Ferrara (2002). Who trusts others? *Journal of Public Economics 85*, 207–234.

Arellano, M. and S. Bond (1991). Some tests of specification for panel data: Monte carlo evidence and an application to employment questions. *Review of Economic Studies 58*, 277–297.

Arellano, M. and O. Bover (1995). Another look at the instrumental variables estimation of error-components models. *Journal of Econometrics 68*, 29–51.

Attanasio, O. P. and G. Weber (1993). Consumption growth, the interest rate and aggregation. *Review of Economic Studies 60*, 631–649.

Barro, R. J. (1990). Government spending in a model of endogenous growth. *Journal of Political Economy 98*, 103–125.

Barro, R. J. and X. Sala-i-Martin (1999). *Economic growth*. Cambridge, MA: MIT Press.

Baskaran, T. and L. P. Feld (2009). Fiscal decentralization and economic growth in OECD countries: Is there a relationship? CESifo working paper no. 2721, CESifo, Munich.

Basu, S. (1996). Procyclical productivity: Increasing returns or cyclical utilization. *Quarterly Journal of Economics 111*, 719–751.

Benhabib, J. and R. E. A. Farmer (1994). Indeterminacy and increasing returns. *Journal of Economic Theory 63*, 113–142.

Bjornskov, C., A. Dreher, and J. A. V. Fischer (2008). On decentralization and life satisfaction. *Economics Letters 99*, 147–151.

Blundell, R. and S. Bond (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics 87*, 155–143.

Bodman, P. and K. Ford (2006). Fiscal decentralisation and economic growth in the OECD. MRG discussion paper series 0706, University of Queensland.

Brehm, J. and W. Rahn (1997). Individual-level evidence for the causes and consequences of social capital. *American Journal of Political Science 3*, 999–1023.

Brennan, G. and J. M. Buchanan (1980). *The power to tax: Analytical foundations of a fiscal constitution*. Cambridge: Cambridge University Press.

Browning, M., L. P. Hansen, and J. J. Heckman (1999). Micro data and general equilibrium models. In J. Taylor and M. Woodford (Eds.), *Handbook of Macroeconomics*. Elsevier.

Bruce, N. and S. J. Turnovsky (1999). Budget balance, welfare, and the growth rate: "Dynamic scoring" of the long-run government budget. *Journal of Money, Credit and Banking 31*, 162–186.

Brueckner, J. K. (1999). Fiscal federalism and capital accumulation. *Journal of Public Economic Theory 1*, 205–224.

Brueckner, J. K. (2006). Fiscal federalism and economic growth. *Journal of Public Economics 90*, 2107–2120.

Buser, W. (2011). The impact of fiscal decentralization on economics performance in high-income OECD nations: an institutional approach. *Public Choice 149*, 31–48.

Caballero, R. J. and A. B. Jaffe (1993). How high are the giants' shoulders: An empirical assessment of knowledge spillovers and creative destruction in a model of economic growth. In *NBER Macroeconomics Annual 1993, Volume 8*, NBER Chapters, pp. 15–86. National Bureau of Economic Research, Inc.

Castles, F. G. (1999). Decentralization and the post-war political economy. *European Journal of Political Research 36*, 27–53.

Davoodi, H. and H. Zou (1998). Fiscal decentralization and economic growth: A cross-country study. *Journal of Urban Economics 43*, 244–257.

Di Tella, R., R. J. MacCulloh, and A. J. Oswald (2003). The macroeconomics of happiness. *Review of Economics and Statistics 85*, 809–827.

Domeij, D. and M. Flodén (2006). The labor–supply elasticity and borrowing constraints: Why estimates are biased. *Review of Economic Dynamics 9*, 242–262.

Drukker, D. M. (2003). Testing for serial correlation in linear panel-data models. *Stata Journal 3*, 168–177.

Durlauf, S. N., P. A. Johnson, and J. R. W. Temple (2005). Growth econometrics. In S. Durlauf and P. Aghion (Eds.), *Handbook of Economic Growth*. Elsevier.

Easterly, W. (2001). The lost decades: Developing countries' stagnation in spite of policy reform 1980–1998. *Journal of Economic Growth 6*, 135–57.

Ebel, R. D. and S. Yilmaz (2002). On the measurement and impact of fiscal decentralization. Policy research working paper 2809, The World Bank, Washington DC.

Enikolopov, R. and E. Zhuravskaya (2007). Decentralization and political institutions. *Journal of Public Economics 91*, 2261–2290.

European Commission (2007). Statistical annex of European economy. Autumn 2007, Luxembourg.

European Commission (2008). Taxation trends in the European Union. 2008 edition, Luxembourg.

European Commission (2011). Taxation trends in the European Union. 2011 edition, Luxembourg.

European Commission (2012). Statistical annex of European economy. Autumn 2012, Luxembourg.

Fan, C. S., C. Lin, and D. Treisman (2009). Political decentralization and corruption: Evidence from around the world. *Journal of Public Economics 93*, 14–34.

Fernández, E., R. Pérez, and J. Ruiz (2010). Double dividend, dynamic Laffer effects and public abatement. *Economic Modelling 27*, 656–665.

Fisman, R. and R. Gatti (2002). Decentralization and corruption: Evidence across countries. *Journal of Public Economics 83*, 325–345.

Frederiksson, A. (2007). Compositional and dynamic Laffer effects in models with constant returns to scale. Technical report, Stockholm University, Department of Economics.

Fullerton, D. (1982). On the possibility of an inverse relationship between tax rates and government revenues. *Journal of Public Economics 19*, 3–22.

Gong, L. and H. Zou (2002). Optimal taxation and intergovernmental transfer in a dynamic model with multiple levels of government. *Journal of Economic Dynamics & Control 26*, 1975–2003.

Grossmann, V., T. M. Steger, and T. Trimborn (2010). Quantifying optimal growth policy. CESifo working paper no. 3092, CESifo, Munich.

Gustavsson, M. and H. Jordahl (2008). Inequality and trust in Sweden: Some inequalities are more harmful than others. *Journal of Public Economics 92*, 348–365.

Hatfield, J. W. (2006). Federalism, taxation, and economic growth. Research papers no. 1929, Stanford University, Graduate School of Business.

Hauk, W. R. and R. Wacziarg (2009). A monte carlo study of growth regressions. *Journal of Economic Growth 14*, 103–147.

House, C. L. and M. D. Shapiro (2006). Phased–in tax cuts and economic activity. *American Economic Review 96*, 18351849.

Iimi, A. (2005). Decentralization and economic growth revisited: An empirical note. *Journal of Urban Economics 57*, 449–461.

International Monetary Fund (2001). *Government Finance Statistics Manual 2001*. Wahington, D.C.: International Monetary Fund.

International Monetary Fund (2010). *Government Finance Statistics*. Wahington, D.C.: International Monetary Fund.

Ireland, P. N. (1994). Supply-side economics and endogenous growth. *Journal of Monetary Economics 33*, 559–571.

Itaya, J.-i. (2008). Can environmental taxation stimulate growth? The role of indeterminacy in endogenous growth models with environmental externalities. *Journal of Economic Dynamics & Control 32*, 1156–1180.

Jones, C. I. (1995). R&D-based models of economic growth. *Journal of Political Economy 103*, 759–784.

Jones, C. I. and J. C. Williams (2000). Too much of a good thing? The economics of investment in R&D. *Journal of Economic Growth 5*, 65–85.

Keele, L. (2007). Social capital and the dynamics of trust in government. *American Journal of Political Science 51*, 241–254.

Knack, S. and P. Keefer (1997). Does social capital have an economic payoff? A cross-country investigation. *Quarterly Journal of Economics 112*, 1251–1288.

Koethenbuerger, M. and B. Lockwood (2010). Does tax competition really promote growth? *Journal of Economic Dynamics & Control 34*, 191–206.

Krueger, A. B. (1999). Measuring labor's share. *American Economic Review Papers and Proceedings 89*, 45–51.

La Porta, R., F. L. de Silanes, A. Shleifer, and R. Vishney (1999). The quality of government. *Journal of Law, Economics and Organization 15*, 222–279.

Laffer, A. B. (1979). Statement prepared for the joint economic commitee, May 20. In A. Laffer and J. Seymour (Eds.), *The Economics of the Tax Revolt: A Reader*. New York: Harcourt Brace Jovanovich.

Leeper, E. M. and S. S. Yang (2008). Dynamic scoring: Alternative financing schemes. *Journal of Public Economics 92*, 159–182.

Lejour, A. M. and H. A. A. Verbon (1997). Tax competition and redistribution in a two-country endogenous-growth model. *International Tax and Public Finance 4*, 485–497.

Ligthart, J. E. and P. Van Oudheusden (2011). In government we trust: The role of fiscal decentralization. CentER Discussion Paper Series No. 2011-073, Tilburg University, Tilburg.

Ligthart, J. E. and P. Van Oudheusden (2012a). The fiscal decentralization and economic growth nexus revisited. Mimeo, Tilburg University, Tilburg.

Ligthart, J. E. and P. Van Oudheusden (2012b). Web appendix to In government we trust: The role of fiscal decentralization. Web appendix, Tilburg University, Tilburg.

Lijphart, A. (1984). *Democracies*. New Haven and London: Yale University Press.

Long, S. J. (1997). *Regression Models for Categorical and Limited Dependent Variables* (Second ed.). Advanced Quantitative Techniques in the Social Sciences. London: Sage Publications.

Long, X. and A. Pelloni (2011). Welfare improving taxation on saving in a growth model. mimeo, University of Teramo.

Mankiw, G. N., D. Romer, and D. N. Weil (1992). A contribution to the empirics of economic growth. *Quarterly Journal of Economics 107*, 407–437.

Mankiw, N. G. and M. Weinzierl (2006). Dynamic scoring: A back-of-the-envelope guide. *Journal of Public Economics 90*, 1415–1433.

Mansfield, E., M. Schwartz, and S. Wagner (1981). Imitation costs and patents: An empirical study. *Economic Journal 91*(364), 907–18.

Martinez-Vazquez, J. and R. M. McNab (2003). Fiscal decentralization and economic growth. *World Development 31*, 1597–1616.

Martinez-Vazquez, J. and R. M. McNab (2006). Fiscal decentralization, macrostability, and growth. *Hacienda Pública Española 179*, 25–49.

Mendoza, E. G., A. Razin, and L. L. Tesar (1994). Effective tax rates in macroeconomics: Cross-country estimates of tax rates on factor incomes and consumption. *Journal of Monetary Economics 34*, 297–323.

Mendoza, E. G. and L. L. Tesar (2005). Why hasn't tax competition triggered a race to the bottom? Some quantitative lessons from the EU. *Journal of Monetary Economics 52*, 163–204.

Miller, A. H. and O. Listhaug (1990). Political parties and confidence in government: A comparison of Norway, Sweden and the United States. *British Journal of Political Science 20*, 357–386.

Mishler, W. and R. Rose (2001). What are the origins of political trust? Testing institutional and cultural theories in post-communist societies. *Comparative Political Studies 34*, 30–62.

Moulton, B. R. (1990). An illustration of a pitfall in estimating the effects of aggregate variables on micro units. *The Review of Economics and Statistics 72*, 334–338.

Novales, A. and J. Ruiz (2002). Dynamic Laffer curves. *Journal of Economic Dynamics & Control 27*, 181–206.

Oates, W. E. (1972). *Fiscal federalism*. New York: Harcourt Brace Javanovich.

Oates, W. E. (1999). An essay on fiscal federalism. *Journal of Economic Literature 37*, 1120–1149.

OECD (1999). Taxing powers of state and local governments. OECD tax policy studies no. 1, OECD, Paris.

OECD (2006). Less than you thought: The fiscal autonomy of sub-central governments. OECD economic studies 43, OECD, Paris.

OECD (2009). The fiscal autonomy of sub-central governments: An update. OECD network on fiscal relations across levels of government, OECD, Paris.

Panizza, U. (1999). On the determinants of fiscal centralization: Theory and evidence. *Journal of Public Economics 74*, 97–139.

Prescott, E. C. (1996). Nobel lecture: The transformation of macroeconomic policy and research. *Journal of Political Economy 114*, 203–235.

Putnam, R. D. (2000). *Bowling alone: The collapse and revival of American community*. New York: Simon and Schuster.

Ramey, G. and V. A. Ramey (1995). Cross-country evidence on the link between volatility and growth. *American Economic Review 85*, 1138–1151.

Rodrik, D. (1999). Where did all the growth go? External shocks, social conflict, and growth collapses. *Journal of Economic Growth 4*, 385–412.

Rodríquez-Pose, A. and R. Ezcurra (2010). Is fiscal decentralization harmful for economic growth? Evidence from the OECD countries. *Journal of Economic Geography*, 1–25.

Rodríquez-Pose, A. and A. Kroijer (2009). Fiscal decentralization and economic growth in Central and Eastern Europe. *Growth and Change 40*, 387–417.

Romer, P. M. (1990). Endogenous technological change. *Journal of Political Economy 98*, S71–S102.

Scrimgeour, D. (2010). Dynamic scoring in a Romer–style economy. mimeo, Colgate University.

Shleifer, A. and R. W. Vishny (1993). Corruption. *Quarterly Journal of Economics 108*, 599–617.

Staiger, D. and J. H. Stock (1997). Instrumental variables regression with weak instruments. *Econometrica 65*, 557–586.

Stegarescu, D. (2005). Public sector decentralization: Measurement concepts and recent international trends. *Fiscal Studies 26*, 301–333.

Strulik, H. and T. Trimborn (2012). Laffer strikes again: Dynamic scoring of capital taxes. *European Economic Review 56*, 1180–1199.

Tanzi, V. (1995). Fiscal federalism and decentralization: A review of some efficiency and macroeconomic aspects. In *Annual World Bank Conference on Development Economics*. Washington, DC: World Bank.

The Conference Board (2009). Total economy database. June 2009, http://www.conference-board.org/economics.

Thiessen, U. (2003). Fiscal decentralisation and economic growth in high-income OECD countries. *Fiscal Studies 24*, 237–274.

Thornton, J. (2007). Fiscal decentralization and economic growth reconsidered. *Journal of Urban Economics 61*, 64–70.

Tiebout, C. (1956). A pure theory of local expenditures. *Journal of Political Economy 64*, 416–424.

Trabandt, M. and H. Uhlig (2009). How far are we from the slippery slope? The Laffer curve revisited. NBER Discussion Paper 15343, National Bureau of Economic Research.

Trabandt, M. and H. Uhlig (2011). The Laffer Curve Revisited. *Journal of Monetary Economics 58*, 305–327.

Treisman, D. (2000). The causes of corruption: A cross-national study. *Journal of Public Economics 76*, 399–457.

Turnovsky, S. J. (2000a). Fiscal policy, elastic labor supply, and endogenous growth. *Journal of Monetary Economics 45*, 185–210.

Turnovsky, S. J. (2000b). *Methods of macroeconomic dynamics*. Cambridge, MA: MIT Press.

UNU Wider (2008). World income inequality database.

Van Oudheusden, P. (2009). Fiscal policy reforms and dynamic Laffer effects. CentER Discussion Paper Series No. 2010-15, Tilburg University, Tilburg.

Van Oudheusden, P. (2011). Dynamic scoring through creative destruction. Mimeo, Tilburg University.

Van Oudheusden, P. (2012). Web appendix to Fiscal policy reforms and dynamic Laffer effects. Web appendendix, Tilburg University.

Warda, J. (2001). Measuring the value of R&D tax treament in OECD countries. STI *Review* NO. 27, OECD Paris.

Woller, G. M. and K. Phillips (1998). Fiscal decentralization and LDC econonomic growth: An empirical investigation. *Journal of Development Studies 34*, 139–148.

Wooldridge, J. M. (1995). Score diagnostics for linear models estimated by two stage least squares. In G. Maddala, P. Phillips, and T. Srinivasan (Eds.), *Advances in Econometrics and Quantitative Economics: Essays in Honor of Professor C.R. Rao*. Oxford: Blackwell.

World Bank (2008). *Worldwide Governance Indicators*. Washington, D.C.: World Bank.

World Bank (2010). *World Development Indicators Online (WDI)*. Washington, D.C.: World Bank.

World Values Survey Association (2009). World values survey 1981-2008 aggregate version 20090901. Aggregate file producer: Asep/jds, Madrid.

Xie, D., H. Zou, and H. Davoodi (1999). Fiscal decentralization and economic growth in the United States. *Journal of Urban Economics 45*, 228–239.

Zak, P. J. and S. Knack (2001). Trust and growth. *Economic Journal 111*, 295–321.

Zeng, J. and J. Zhang (2007). Subsidies in an R&D growth model with elastic labor. *Journal of Economic Dynamics & Control 31*, 861–886.

Zhang, T. and H. Zou (1998). Fiscal decentralization, public spending, and economic growth in China. *Journal of Public Economics 67*, 221–240.